ENGINEERING NEWS

A JOURNAL OF CIVIL, MECHANICAL, MINING AND ELECTRICAL ENGINEERING

Vol. 64. No. 26. 220 Broadway, New York. December 29, 1910.

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The Disposal of Surplus Water and Electric Power from the Los Angeles Aqueduct.

By BURT A. HEINLY.*

With the Los Angeles Aqueduct now 75% completed in point of hardship and 51% in point of distance—the final completion of the work being scheduled for the fall of 1912 or the early spring of 1913—the municipality is preparing to take the preliminary measures for the disposal of the large amount of hydro-electric power as well as surplus water which will be available as soon as the aqueduct is in operation. The accompanying illustrations show the progress of work and may prove of interest, though not directly related to what follows.

The City has been so intent upon the completion of the enterprise that until recently there has been no public discussion of sales of water and power. Today the City realizes that these problems are comparable in magnitude only to the aqueduct project itself.

As to the question of power, the problem is whether the City shall retail the power available or whether the City shall act merely as a wholesaler to the power companies now doing business within the City. If it is decided to retail power there is still another problem—whether the City shall be able to come to some understanding with the power companies by which it may take over their domestic and city lighting systems (leaving them the railways which are annually demanding large increase in power consumption) or whether the City will be required to install its own distribution system and enter into active competition for the business.

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In the disposal of the surplus water, Los Angeles faces rather an intricate situation. An Act of Congress dated June 30, 1906, giving a right of way over public lands provides in Section VI:

> That the City of Los Angeles is prohibited from ever selling or letting to any private corporation or individual, except a municipality, the right for such corporation or individual to sell or sublet the water sold or given to it or him by the city.

The aqueduct is designed to deliver at the San Fernando reservoirs, 20 miles north and west of Los Angeles, a daily supply of 20,000 miner's inches. Of this amount it is estimated that only 2,000 miner's inches will be required for some years, leaving 18,000 to be disposed of for irrigation under whatever conditions the City may decide to impose. Ultimately, as the City grows, in a term of years it is expected that this entire surplus of 18,000 ins. will be required for domestic consumption. The problem which confronts the City is to place this water upon contiguous horticultural territory which will gradually become urban as the City extends its population and boundaries.

There is no desire on the part of City officials to sell the water outright and make it appurtenant to the land (as is very often the case in irrigation procedure in this country), but even so, it is hardly possible that such could be accomplished as it would require the ratification of a two-thirds vote of the people, who today are practically of one mind in their wish that the City shall retain the perpetual ownership of all the water of the aqueduct.

To gain a knowledge of what the people desire, the Mayor, the City Council, the Board of Public Works and the Board of Water Commissioners for the past two months have held from one to three public meetings a week, forming what the press has been pleased to call, "The Public Forum." Not only citizens and representatives of public bodies have been asked to express their views, but this invitation was extended to all nearby municipalities which may in any likelihood seek an additional water supply from the aqueduct.

These sessions of City officials who are to have the disposition of two of the City's greatest resources, may be likened to the old time New England town meeting at which every citizen was permitted to express his opinion, but they are certainly unique in the proceedings of the large and modern city. The meetings have been largely attended and have brought forth spirited discussion of the City's future course of action.

No definite plans for the disposal of the large quantities of surplus water and electric power have yet been evolved but the following transcript of remarks, or "suggestions" made by Mr. William Mulholland, Chief Engineer of the aqueduct, his assistant, Mr. J. B. Lippincott, and Mr. E. F. Scattergood, Chief Electrical Engineer, will give what will very probably form the groundwork for plans for the proper distribution and sale of the two commodities.

FIG. 1. A DIPPER DREDGE AT WORK IN THE AQUEDUCT CANAL, OWENS VALLEY.

FIG. 2. SIDE-HILL WORK ALONG THE LOS ANGELES AQUEDUCT, IN THE GRAPE VINE DIVISION.
(Showing conduit form used.)

Suggestions for the Discussion of the Disposal of the Water Supply from the Los Angeles Aqueduct.

By WILLIAM MULHOLLAND,* M. Am. Soc. C. E.

Primarily, the Los Angeles Aqueduct is being built to supplement the water supply of the City of Los Angeles. The investigation of the available supply in the Owens River Valley led to the conclusion that a capacity of 20,000 miner's inches (400 cu. ft. per sec., 259,200,000 gals. per day) was warranted by reason of the fact, first,

*Chief Engineer of the Los Angeles Aqueduct.

that this quantity of water could be obtained, and second, that the City of Los Angeles and the surrounding country could easily use that much in their future development. The larger the aqueduct could be built, the more cheaply could any unit quantity of water be delivered by it. Hence the aqueduct was designed to carry the full quantity that might, with certainty, be available.

The present water supply of the City of Los Angeles amounts to about 65,000,000 gals. per day, which might be reduced, by the occurrence of a few dry years in succession, to a less quantity than would meet the demand. The largest demand of the present year amounted to 54,250,000 gals. per day, which occurred on July 19, 1910.

It may be assumed that the demand for water for municipal use will increase in direct proportion to the population. Assuming an average per capita consumption the year round of 140 gals. per day, and an increment in population of 15,000 per annum, the amount of water consumed each year by the city in excess of the previous year is 2,100,000 gals. per day, or about 130 miner's inches.

The pipes of the water system of the City of Los Angeles serve an area of about 24,000 acres. As the average daily consumption is about 40,000,000 gals., or 3,094 miner's inches,* it will be seen that an inch of water serves 7.75 acres of the City's area. If we assume that this whole area is about two-thirds built up, we arrive at the figure of a little over five acres to an inch.

As the population of a city becomes more dense the per capita consumption with proper restrictions in the way of meters, etc., becomes much less and according to our experience may fall as low as 30 or 40 gals. per capita per day in the congested areas. Also, it may be stated that as a city extends its area the sparsely settled districts will in general bear the same proportion to the congested districts as when the city was smaller.

The purpose of these statements is to demonstrate that in disposing of the surplus water, it should be kept in mind that the territory served should be adjacent to the city, and capable of final absorption by annexation. Should this be done, no reason would ever arise for severing the water from the land to which it would be applied, as the process of assimilation would completely settle the question.

of Los Angeles to incur the great indebtedness necessary to build the Los Angeles Aqueduct, without the expectancy of other return than that derived from the sense of security in her water supply and the development and increased productiveness, with all incidental benefits, of her surrounding country; or, should she require the country so directly benefited to contribute in some part toward the cost of the project?

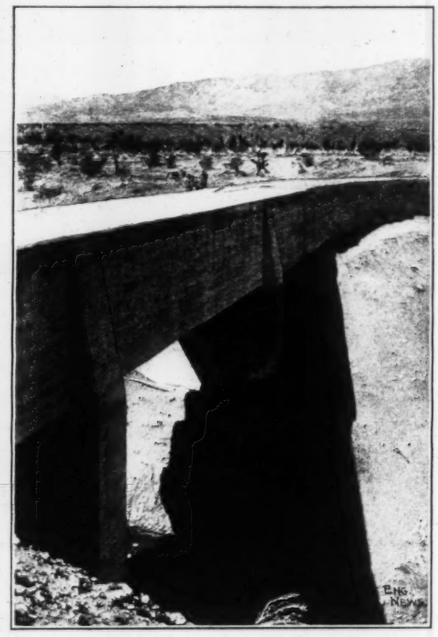


Fig. 3. Concrete Flume Across Cottonwood Wash in the Mojave Division of the Los Angeles Aqueduct.

Assuming that the City has enough water from its present sources to supply the needs of the area now supplied, and that 2,000 ins. additional to that will amply care for the area not now supplied within the city limits (and this we believe to be a liberal provision, when it is considered that the free use of water for irrigation in the San Francisco valley will result in a great accession to the Los Angeles River, all of which will be available for diversion at will by the present works), 18,000 miner's inches are left for disposal to outside territory, which on the basis of 1 in. to 7½ acres would supply 135,000 acres. As this area would include roads and waste places, and also, as there are means afforded to store the winter surplus for summer use, the result in practice, even allowing for all unavoidable waste, would exceed 1 in. to 5 acres.

How then shall this water be disposed of so that the burden of the expense of procuring it shall be evenly borne by the beneficiaries?

It will doubtless be contended by the landowners that if they pay for the water as they receive it, they will be doing all that should be asked of them. The answer to this is that the people of Los Angeles will also be paying for the water they use, in addition to annual tax levies for the cost and interest on the bond issue for the aqueduct construction, from which outside land-owners are wholly exempt. When it is considered that all, or most of the land that may be served by the Owens River water, is now without an adequate water supply, and considering all of the other conditions above set forth, as to permanence of attachment of the water to this land, the principle of charging a substantial sum per acre, by way of bonus, suggests itself as the only one. What this amount should be is a matter of business consideration, and may be gaged entirely by the difference in value between the land in its present condition and its value with an abundant and reliable water supply, such as the aqueduct will afford.

The problem of a supply for the neighboring towns will also have to be met, but a fixing of a charge for water for this purpose is not as difficult as might first appear. Take the case of the City of Los Angeles. The cost of delivering water to its inhabitants is about 4½ cts. per 1,000 gals. Of this sum, 1½ cts. pays all the cost of putting the water into the distributing reservoirs, including interest on the cost of reservoirs, conduits, dams, intakes and pumping charges together with interest on the book value of the water at $1,000 per in. This amounts to almost exactly $75 per in. per annum, and if we allow, as above suggested, 1 in. to serve 7½ acres, the cost for irrigation purposes would be $10 per acre per annum, and in the opinion of the writer this would be the proper charge for water to towns, the distribution charges afterwards to be borne by themselves.

The rate of $10 per acre per annum is one that is fully justified by the average cost of water for agricultural purposes in Southern California, and is one that farmers can afford to pay, so that in effect under the rates in the subjoined table the rate is the same whether for town use or agricultural purposes.

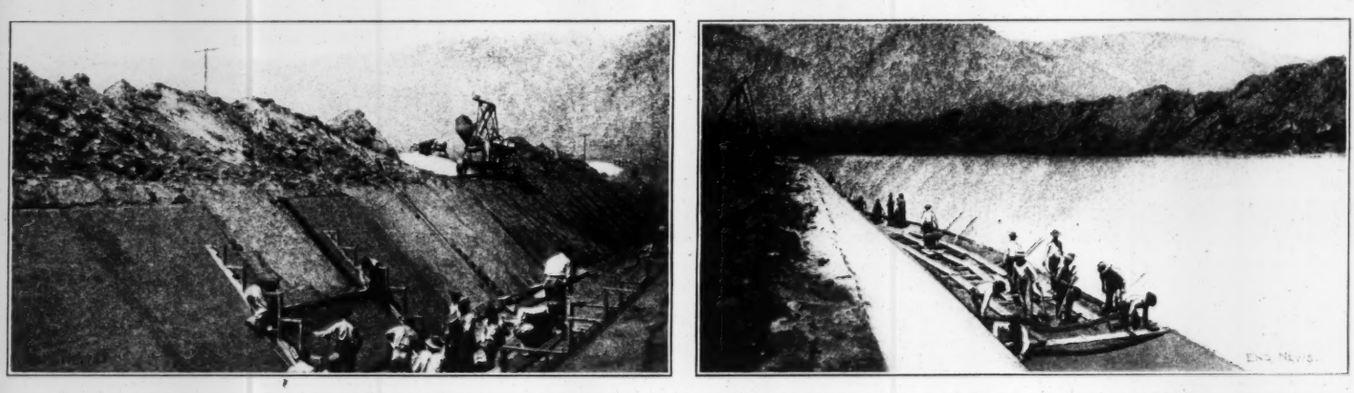
SUGGESTED RATES.

For towns.....	$375.00 per miner's inch bonus.
For towns.....	75.00 per miner's inch per annum.
For irrigation.....	50.00 per acre bonus.
For irrigation.....	10.00 per acre per annum.

On the basis of this schedule, the City would receive $6,750,000 as straight bonus on the 18,000 ins. she would have to dispose of outside the present territory and would receive an annual revenue of $1,350,000 gross.

While these figures show that considering the water alone, the City would still be carrying more than its proportionate share of the burden, the value of the power to the City would much more than offset the difference, in addition to which the City would receive the very large indirect benefit due to the enhancement of production of the surrounding country.

If it is assumed that it will take $2,250,000 to build the reservoirs and trunk lines to lead to the various districts that might contribute bonus on the above schedule, then there would be invested in the Owens River aqueduct, and appurtenances, the sum of $26,750,000. Should the City receive



FIGS. 4-5. CONCRETING THE SIDES AND BOTTOM OF THE CONDUIT IN OLANCHA DIVISION, NEAR OWENS LAKE.

The happy coincidence that a complete cultivation of the average lands in Southern California, other than those in the damp areas, requires at least 1 in. to 7½ acres, makes the solution of this problem an easy one, as it will not matter ultimately whether the lands are used for urban or agricultural purposes, as the water applied will always remain in sufficient quantity for either use.

The financial aspect of the question, however, is capable of many different constructions. The question may be asked: Is it proper for the City

[*Mr. Mulholland's figures are printed as quoted; his value of a miner's inch is that used in Southern California, based on a 4-in. head and is equivalent to 1.2 cu. ft. per sec. or 9 gals. per min.—Ed.]

the bonus above indicated ($6,750,000), her indebtedness then for the aqueduct would be an even $20,000,000. If it is assumed that the distribution of the water, maintenance of the aqueduct, and all administration charges amounted to $350,000 per annum, which by the way is a somewhat extravagant figure, then the net revenue to the City would be $1,000,000, which is 5% on the $20,000,000 debt.

Of course it will be remembered that these figures are presented merely for the purpose of opening a broad discussion on this subject, and may be modified in either amounts or principles of application. We believe, however, that they would be accepted as reasonable by the people and all prospective water consumers.

The $1,000,000 net would not represent all the earnings, as the amount of 2,000 miner's inches assigned to the City would at least earn its $75 per in. per annum, yielding $150,000 net as charges for distribution would be wholly absorbed in the general administration charges of the Water Department.

It might be further suggested that any water disposed of above an elevation of 1,450 ft. might properly be charged with the loss of power that would occur by the abstraction of the water from the drop of 300 ft. into the San Fernando Reservoir and where it is designed a power plant shall be installed. This loss would amount to slightly over ½ HP. per miner's inch hence, if it is assumed that the power has a potential earning value of $25 per HP. per annum net, the additional charge to equalize this would be $12.50 per miner's inch per annum in addition to the base price of $75 per in. above suggested.

Suggestions on the Sale of Water for Agricultural and Horticultural Uses.

By J. B. LIPPINCOTT,* M. Am. Soc. C. E.

As a matter of course it is desirable from every point of view promptly to put the aqueduct into full beneficial service, both as a source of water and power supply. There are four "drops" in the line where power plants may be built. Manifestly, they should be built one at a time and developed as the market for power grows. To build one plant for the development of, say one-fourth of the power, means that a full head of water should pass that one site. This being the case it is essential that a prompt and beneficial use should be found for the largest possible amount of water upon its arrival at our doors.

The peculiar delta-like character of the drainage lines in our Southern California valleys is such that this large volume of water could not be discharged into the drainage lines, for it would wander from these courses through cultivated fields and thickly populated districts, doing serious damage.

The prompt use of the water, which for the present is surplus, for irrigated agriculture and horticulture, is the solution, storing the winter flow in suitable reservoir sites which may be found near the city.

We have talked about the domestic use of water as being the highest use to which it can be put, and, we are agreed to that. Water, when it is necessary for drinking purposes, is beyond estimate in value—it is an absolute necessity. Outside of its use for a domestic supply, in my judgment, the greatest value that it will have for this community, and for Southern California, will be the service it will render in agriculture and horticulture, as these are, the basis of all our wealth.

We estimate that there will be sufficient surplus water for the irrigation of 135,000 acres of land. There are few who have a comprehensive and accurate idea of how large an area this is. Today, the total irrigated area of Southern California, west of the Coast Range, from Santa Barbara to San Diego (about 200 miles) is only 250,000 acres. It is a very moderate estimate to say that the gross value of the products per acre raised on these selected semi-tropic lands, would be $100 per annum.

I believe there will be ultimately resulting from the cultivation of this 135,000 acres of land, $13,500,000 annually distributed in the broadest and best way, throughout the entire community. This would be among the actual laborers in the field, owners of the land, commission men, railroad companies and everybody who goes to make up a Southern California community. It will be the greatest asset, in my judgment, that will come from the building of the aqueduct, outside of the actual and strictly domestic use that our water will be put to, and consequently it is my belief that the policy of the City should be rather to encourage and foster the development of horticulture and agriculture in connection with the use of this water. We realize that the power will be valuable, but I believe the value of the water in an agriculture sense will be greater.

Mr. Mulholland in his "Suggestions" has already spoken of the gradual transition of an agricultural region into a suburban and then into an urban area. I have no doubt whatever but that if the water is used judiciously and properly put upon the lands surrounding the City of Los Angeles for agriculture, there will never be any occasion whatever, to take the water off those lands. Personally, I would have no more fear of having a water supply that was given to me under these conditions, taken off of my land, than I would have of having it taken away from my home in the city. I have no water rights, nor do I need them. I believe that the City will act fairly in this matter and with the farther argument of the beneficial use to which the water is being put, I believe there is no danger of the water being removed from the farm.

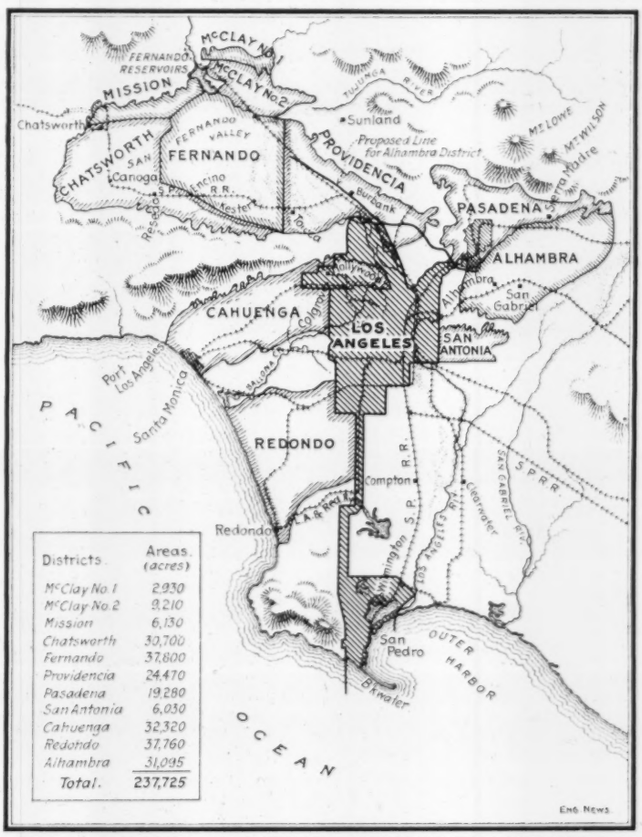


FIG. 6. MAP SHOWING DISTRICTS ADJACENT TO LOS ANGELES TO WHICH IT IS PROPOSED TO SUPPLY WATER.

With reference to the situation in Los Angeles, we have been transformed gradually from a Spanish agricultural district into a city. We have all seen within the last few years the same process at Hollywood (now an outlying suburb of Los Angeles). We have seen a small horticultural district obtaining water from the San Fernando Valley grow and develop. We have seen controversies over the ownership of that water; we have seen the City win that suit, and in spite of the fact that the City won, there has been no aggressive enmity displayed.

A reasonable opportunity was given Hollywood to obtain another supply, and the City has settled the matter in an equitable way along those lines and Hollywood has now been added to the City.

The distribution of the water is a very large question—and it is largely an engineering question in this particular; it will be necessary from an engineering standpoint to lay off districts, which are controlled by topographic conditions—districts that have natural topographic boundaries. For instance the district lying between Los Angeles and Redondo is one (see Fig. 6). Along the base of the Cahuenga range is another natural topographic district. The San Fernando Valley is another natural division, etc. These districts, it is my belief, should be fixed by natural topographic boundaries. When they are laid off, enough water should be supplied for the entire district. In forming these districts and in entering into relations with them, care should be exercised that the combined areas of all the districts to which water is supplied should not be in excess of the total water supply we have available.

Outlining and expanding the last statement:

(1) In determining the areas to be supplied with water, topographic districts should be outlined which can be served to advantage, physically and economically, by mains and distribution systems.

(2.) In building a main and distribution system to a given district, the conduits should be large enough and the supply adequate to furnish ample water to all lands or inhabitants therein. Manifestly it would be unjust to serve one man with water and subsequently refuse it to his next-door neighbor, especially in districts that are either presently or prospectively destined to be urban or suburban in character.*

(3.) If water is taken at present for only a scattering portion of the inhabitants, or of the land in a district, the distribution system will have to be as extensive and almost as expensive as if it were built to serve the entire area, thus involving an improper expenditure and an undue burden upon those using or supplying the water.

(4.) As the area contiguous to the city upon which the water may be supplied, is greater than that which the water available can adequately serve, and as it is important to the city to promptly market its water and obtain revenues therefrom, it will not be economically proper to hold, in reserve, water for land not promptly paying for it, which land would be greatly benefited therefrom in a speculative way and without cost. Such a procedure would probably prevent other districts which are willing to pay for the water from being supplied at all. Nor would it be fair to permit one living in a district, who is subsequently willing to pay, to afterwards take a portion of the water previously purchased by his neighbor.

(5.) If it is accepted that when a district is supplied with water, both the distribution system and the amount of water therefor must be ample for the entire area, then some plan should be devised for dealing with organized districts having power to contract with the city under the Federal, State and Municipal laws.

*Assistant Chief Engineer of the Los Angeles Aqueduct.

In conclusion: We realize that the City has bonded itself for an aqueduct and for power plants, practically to the limit of its bonded indebtedness. The construction of a distribution system to cover 135,000 acres of land, is an expensive proposition. It will be necessary for some one to pay for the construction of those works. I do not believe that the City, at the present time, is in a condition to do this, but a district, if properly organized, might meet such an expense. Furthermore, I think that it is only just and proper that the City after going to such a large expense, in connection with the construction of the aqueduct, should be able to require from such districts, as has been suggested, a very substantial bonus, not for a water right, but for the privilege of using the water.

Suggestions on the Disposition of Electric Power.

By E. F. SCATTERGOOD,*

The state of the City's finances must necessarily be considered in connection with suggestions as to the utilization of the Los Angeles Aqueduct power. The amount of bonded indebtedness of municipalities of this State is limited by an Act of Legislature to 15% of the assessed valuation. This leaves a margin for the City of Los Angeles at the present time of something like $10,000,000 over and above all outstanding bonds and together with those authorized by the people but not as yet issued. It is true, however, that it is not desirable to increase the bonded debt of the city beyond that which is absolutely necessary and for this reason it seems appropriate in discussing the power question to point out the desirability of giving every consideration to the policy of requiring a considerable bonus in connection with a rental in making up the total compensation received by the city for surplus water. The amount suggested by Mr. Mulholland may be increased or decreased, but, as suggested by him, it would mean something like $6,000,000 which would provide the necessary $2,500,000 for main distributing conduits from the San Fernando reservoirs to this City and to the various irrigating districts, and at the same time, would materially relieve the City's bonded debt. From these remarks it appears that the City is free to adopt whatever policy seems best, having in mind the City's interest and the public good in this community, and that it is not necessary for the City to consider sacrificing its best interests in order to avoid additional indebtedness in the utilization of its power.

The amount of power which may be developed at the various power sites along the line of the aqueduct, together with some 7,000 HP. from the Cottonwood and Division Creeks in the Owens River valley, is such as to deliver in the City at a central sub-station an average of 64,000 HP., after making liberal allowance for all losses, and owing to the provision of regulating reservoirs in connection with two of these power sites it will be possible to deliver this in accordance with the demand during any 24 hours up to a peak-load of 120,000 HP.

As shown in the preliminary report of the Consulting Board of Electrical Engineers,† made for the information of the public previous to the bond election of April 19 last, this power is not only unusually reliable as hydro-electric power, but can be delivered here at a very low cost as compared with the average hydro-electric power project in the West. The assurance, then, of a large amount of hydro-electric power under public control susceptible of development at very low cost should go a long way toward encouraging capital and toward encouraging manufacturing in this section, especially in connection with an assured water supply and ample harbor facilities under public control. The average peak-load for all purposes as supplied by the various electric companies within the City limits is at the present time something like 50,000 HP., and for this section, including Pasadena, Long Beach, Santa Monica and the intervening territory, is something like 80,000 or 85,000 HP. From this it appears that possible power to the extent of 120,000 HP. peak-load, should very materially affect the cost to manufacturers and consumers. The City should realize a direct profit from the development of this power, but this will not represent its greatest benefits, and should not be given more than due consideration. To dispose of large blocks of power to industries employing but few men would be a mistake.

Conditions here seem to justify an original development of something like 30,000 to 40,000 HP. The cost of delivering at a central sub-station in the city a 30,000 HP. peak-load as the first installment will not exceed $2,250,000 and the cost of a complete distributing system, reaching all consumers within the present city limits for light and power, including street lighting, would be approximately $4,250,000, such distributing system taking care of a business 50% greater than the present and adaptable to extensions without extra expense. In order to give an idea of values in connection with the commercial and street-lighting business and not for the purpose of recommending any particular rate, profit or policy, it may be stated that assuming that the city or any single concern with the investment of $6,500,000 in the properties mentioned, had all of the commercial light and power business and street lighting, but excluding railway power, it could establish a 6-ct. base rate with a corresponding scale for light and power, and, receiving credit at the rate of $60 per arc lamp per year for street lighting as against the present rate of $76.30, show an excess earning of something like $700,000 per annum, after allowing for all operating expenses, interest on the $6,500,000 at 4½%, sinking fund of 2½% and proper depreciation. These results are based on conservative estimates, but could not be acomplished with several distributing systems and several organizations operating to supply the same service.

At the time the issue of $3,500,000 of bonds for power purposes was recommended, the charter limitations would not permit of more. The conditions in regard to aqueduct construction were such as to necessitate the expenditure of some $300,000 in temporary work in order to pass the water by power sites unless certain work in connection with the power plants was provided for at the same time. The necessity for providing funds promptly in order to make it possible for the city to profit by such opportunities at the completion of the aqueduct was recognized also, and as pointed out by the Mayor during the bond campaign, $3,500,000 would not only generate an appropriate amount of power, 30,000 HP. peak load, as stated, but would leave at least $1,250,000 for distributing purposes, which would cover a substantial portion of the city and result in a working system. So much being accomplished, it is evident that additional funds should be provided for extending over the whole city, which work could be accomplished in a comparatively short time after such funds might become available, thus placing the system in a position to make a much better showing, whether it should have the whole business of the city, as suggested in the foregoing hypothetical case, or be under the necessity of competing for business, in which case the showing which the system could make would be quite different, but the benefits to the consumer no less. The present peak load for light and power in the city, excluding railway power, is approximately 17,500 HP., so that 30,000 HP. would care for several years' increase.

The wording of the ordinance calling the bond election and the ballot by which the people in the ratio of seven to one authorized the issue of $3,500,000 of bonds indicate an intention to provide in some way for both the development and the distribution of aqueduct power. It is believed that the city will endeavor to purchase the existing distributing systems at a fair valuation, and not proceed to install an independent system unless forced to do so. This would be much better for the city and the companies as well.

It has been suggested by many that the city should sell to the existing companies for distribution and resale by them to the inhabitants. The city and its inhabitants have patronized the companies in the past, and now has its own commodity, and so long as it stands ready to purchase existing distribution systems at a reasonable price there is no justification for such a claim. The question is raised as to the effect on the generating systems of the combined companies. Their statements to the City Council of January 1 show that approximately 20% of the total power generated is used in connection with the business in question, being all commercial light and power, including street lighting, but excluding railway power within the present city limits. It is a fact that the yearly increase in the generating business has been 20% for many years, from which it is evident that with sufficient notice neither the value of such generating systems nor their usefulness would be impaired. There is room in Southern California for all. It is simply a question of the city's sharing in the business at least to the extent of its own consumption exclusive of railways. Reports of companies to the Council show that their distributing costs in connection with this service are something like $400,000 greater than a very liberal estimate on these costs to the city for supplying the same service. The proposition of selling to companies for resale to the city and its inhabitants, therefore, could not be contemplated. It would perpetuate a constant temptation to interfere with the city's politics, as well as the unfortunate condition of a number of its best citizens having interests conflicting with the city's best interests. It may be said that the people here have made the city in which they live rather than to have been born in it. They have a good understanding of civic affairs, and the city has had succesful experience in handling municipal works of magnitude. Cheap power is not and will not ever be plentiful in this section, and is a matter of sufficient importance to justify public interest.

*Electrical Engineer of the Los Angeles Aqueduct.

[†See Eng. News, March 24, 1910, p. 324.—Ed.]

The Over-Running of Signals Standing at "Danger."*

By M. HOOGEN.

Attempts to supplement the visible signals by audible signals, as well as proposals to prevent one train from running into another, by means of special devices not depending on the attention of the locomotive driver, date back to nearly the beginning of railways. But such devices have only been used in very few cases and only during very short periods of time on German railways and on railways in other countries.

Opinions both here and abroad still differ widely as to the conditions which such a system should satisfy. The first serious attempt, on German railways, to elucidate the question whether and under what conditions it would be advisable to supply auxiliary means for drawing the attention of the driver to the signals and for stopping the train in case of danger, was made in February, 1901, when at the invitation of the German State Railway Office representatives of nearly all the German States met to discuss what measures should be taken in order to increase the safety of the traffic. The agenda of this meeting included *inter alia* the following two items: "Experiments for supplementing distant signals by audible signals" and "Devices for stopping a train by operating the compressed-air brake."

The results which had been obtained by the combination of audible and visible signals were at that time considered unsatisfactory; it was therefore agreed to submit the question to a commission, which was to ascertain what devices were in existence, and to make tests; and which eventually might draw up proposals for the general introduction of such audible signals. Devices for stopping a train by operating the compressed-air brake from without were not considered expedient; but this question was also to be carefully investigated by the commission.

Experiments were thereupon made in Saxony with the "crocodile" contacts of the French Northern Railway, and with an audible signalling device operated by carbonic acid; in Baden a so-called "distance" brake was tried. In neither case were the results satisfactory. In Prussia, a special committee was appointed to examine the many inventions of this kind which were submitted; but nothing useful was found.

In the meantime, the German Verein had also been considering the question. The Austrian Railway Ministry addressed a letter dated Dec. 12, 1901, to the acting committee of the Verein, in which attention was drawn to the fact that in consequence of accidents which result from the over-running of signals standing at danger, there is a continual repetition of the demand for de-

*From the "Zeitung des Vereins Deutscher Eisenbahnverwaltungen," as reprinted in the "Bulletin of the International Railway Congress Association" for November.

vices for showing the driver that the line is blocked, not only by means of the visible semaphore, but also by means of another audible or other signal on the locomotive, and in some cases by the automatic operation of the brakes, by automatically cutting off steam, etc. The Austrian Railway Ministry therefore proposed that it should be determined, in the first place, whether such devices were really suitable for increasing the safety of the traffic to the extent desired. This proposal was brought before the technical committee, and referred by them to a sub-committee, consisting of eleven members for consideration and report. It was subjected by them to very careful examination.

The sub-committee, after sending inquiries to all administrations belonging to the Verein, answered the question raised by the Austrian Railway Ministry, by stating that devices for informing the driver that a signal is at "danger" by means other than those at present in use (for instance, audible or other signals on the locomotive) are considered advisable, but that such devices must satisfy the condition of being absolutely reliable in their working. Devices which satisfy this condition are not known. Devices for automatically applying the brakes or cutting off steam, without the intervention of the driver, are considered inadvisable.

When the question was discussed by the technical committee at its meeting at Trier, June 10-17, 1904, they adopted the answer proposed by the sub-committee but expressed the opinion that in order to be absolutely reliable, the devices should at least satisfy the following conditions:

(1) The device must not only show that the corresponding stationary signal is being approached, and its eventual position at "danger," but also any defect in the device which would prevent its proper action.

(2) As far as stationary signals are concerned, the device must act soon enough to make it possible to stop the train with certainty before reaching the signal in question.

(3) The perception of the signal must not necessitate any previous attention on the part of the driver; on the contrary, the presence of the signal must at once make itself apparent to the driver in an unambiguous way, under all the conditions which may arise on a locomotive. The indication must be given whether the locomotive is running stack first or tender first. It must only act with trains running in the direction to which the signal in question applies.

(4) The device may only stop acting if the locomotive is standing still. Any switches are admissible only if they are so constructed that the locomotive can not be started unless they are in the correct position.

(5) The device must be arranged so that its action can not be stopped maliciously or unintentionally. The sign must not be given unintentionally by any obstructions on the track, which do not affect the running of the trains.

(6) Unauthorized persons should not be able to put a signal on or to pull it off.

(7) The upkeep and supervision of the device must not be attended with any particular difficulty.

(8) It must be possible to give the stop signal on the locomotive, without any particular difficulty or lengthy preparation, at each of the places so equipped, from any point that may be convenient.

These resolutions of the committee were adopted by the general meeting of the Verein, held at Danzig Sept. 1-3, 1904. The next year a number of devices were again submitted, which were to satisfy the conditions defined above. But at first none of the devices submitted proved to be satisfactory. Only towards the end of 1906 were a few devices submitted, which were sufficiently developed to make it advisable to try them. The administration of the Prussian State Railway thereupon started to make systematic trials of them in ordinary working, on a larger scale, devoting considerable funds to the purpose. Particulars of these trials, which had then just begun, were published in the "Zeitung des Vereins Deutscher Eisenbahnverwaltungen," 1907, No. 48.

The first trials there mentioned, with double-light distant signals, are completed. According to the decision of the council of March 10, 1910, this pattern of distant signal is to be substituted for that formerly used. The results obtained in Saxony and on several large trial sections on the Prussian State Railway prove beyond doubt that the perceptibility of the distant signals in the night time is materially improved by this arrangement. It is to be expected that this alteration will be completed in a few years; the limit fixed for carrying it out is the end of 1919. No doubt a good effective distant signal will for a long time to come remain the most effective means for preventing the overrunning of the main signal. Hence it may also be expected that this improvement of the distant signal will make it easier to attend to the stop signals.

Experiments with combined detonating and visible signals have been made on the larger scale in the districts of the Bromberg, Cologne, Münster and Stettin directorates. The detonation and the light produced by the detonators used suffice to attract the attention of the driver. The attendance is simple, if it can be carried out from an existing signal cabin. The cartridges, usually three in number, are placed on the rail by a lever mechanism operated from the signal cabin.

When this machine was intercalated in the wire transmission of the signal, in one of the directorate districts, difficulties arose, although the machine was in immediate connection with the wire transmission of a block signal. The movement of the signal was so much impeded, that the machines had to be disconnected during part of the winter.

Moreover during the trials doubts arose, whether persons and vehicles would not perhaps run considerable risks if such signals were used near habitations or streets running alongside the line. This would prevent their use for distant signals, which are more frequently overrun when standing at "danger." But even leaving this out of consideration, the detonating signal, which originally represented a danger and stop signal, is hardly suitable for indicating that a distant signal stands at "caution."

In a further series of experiments, which were carried out by the Altona, Halle, Kattowitz and Stettin directorates, electrically-operated sirens and horns were placed in front of the distant signals. When the head of the train reaches a contact which is placed 300 meters (328 yards) in front of the distant signal, the latter standing at "caution," the siren or horn begins to sound and continues to do so until the head of the train reaches another contact placed 50 meters (55 yds.) behind the distant signal. The control of the proper working of the appliance is effected by an indicator in the signal cabin. These experiments are not yet concluded. In the case of goods trains the sound of the siren has as a rule sufficed to attract the attention of the driver. In the case of passenger and express trains, the sound appears not to be sufficiently strong. In one case, the appliance had to be removed because people living in the neighborhood were inconvenienced by the loud sound of the siren.

While these devices are intended to notify, by an audible signal given from a stationary point next to the track, that a signal is being approached, the electric signal-indicator is intended to give the audible signal notifying the approach to a distant signal, on the locomotive itself. When the train approaches the distant signal, a brush fixed to the locomotive comes into contact with two fixed contact bars placed next to the track. The armature of a relay on the locomotive drops off, a red disk appears and an alarm is switched on, which the driver can again stop by a push.

The Hanover, Stettin and Breslau directorates have made experiments with this appliance. In Hanover two express, two passenger and two goods locomotives are equipped in this way; contact bars are placed before all distant signals of the home and block signals, both directions, on the very busy section Wunstorf-Minden. The results of these trials have not yet been wholly satisfactory. Minor defects in the indicators have, it is true, been gradually eliminated. The contact brushes have, however, been repeatedly damaged by ballast and by other objects projecting into the boundary of the loading gage, although the steel-wire brushes seem particularly suitable for making proper contacts even when the locomotive oscillates, and for yielding to any obstructions. When running at high speed the appliance still sometimes fails to act.

The van Braam train-safety apparatus, on the other hand, attempts to solve the problem by purely mechanical means. It consists essentially of a pair of slippers mounted on the locomotive. If these slippers slide on raised treadles placed alongside the rails, a rod is pulled downwards. This moves a catch, which under ordinary conditions prevents two spindles from being turned by a spiral spring, which is in a state of tension. When the catch is disengaged, the spindles are turned by the spiral spring. The movement can be utilized for starting the compressed-air brake, for making a colored disk appear and for operating a recording instrument.

Trials with the van Braam apparatus have been made on the Prussian State Railway in the districts of the Halle, Danzig and Breslau directorates. Ten express locomotives have been so equipped in the Halle district alone. Trials are also being made in the Hanover district. In these trials, in accordance with the opinion expressed by the meeting of 1901 and the resolutions, of 1904, of the technical committee of the German Verein, the action on the brakes has been eliminated, because it was thought that this might in course of time weaken the feeling of responsibility and the attention of the drivers; moreover, it would make the apparatus more complicated and consequently more unreliable. The recording instrument has only been tried in the Danzig trials, as it is not of great importance if the slippers only act at the distant signal, which it is permissible to over-run even when it is standing at "caution." We may however at once draw attention to the fact that in the case of experiments made with this apparatus it is primarily of minor importance how the movement which the treadles produce on the locomotive is utilized. The chief difficulty consists in making the arrangements for the transmission reliable and durable. The experiments, particularly those carried out with great care by the Halle directorate, have given useful information for determining the value of this apparatus.

The turning on of the steam whistle is reliably effected at speeds of from about 20 kilometers (12.5 miles) per hour upwards, if the slippers and the treadles are in order. Unintentional turning on has occurred. It is true that there is not much risk of this, because as the van Braam apparatus is arranged, it is necessary for both slippers to be raised before the whistle or brake is affected. In several cases the slippers were broken, although special care was taken on the experimental sections that there should be the proper clearance. The cause of this is that a depression of 5 millimeters (3/16-in.), of the slippers suffices to make them strike objects which are outside the loading gage proper, but very near to its boundary, such as guard baulks on bridges, check rails at cross-overs, stiffener brackets on bridges, etc.

Experiments made however show that oscillations of up to 25 millimeters (31/32-in.) actually occur. The guard baulk of a bridge, which was only 35 millimeters (1⅜ ins.) above rail-level, and hence still 15 millimeters (19/32-in.) from the boundary of the loading gage, was found to bear slipper marks. Similar observations were made at other places. It follows that as present constructed the slippers are liable to strike objects and become broken.

During the trials, moreover, difficulties arose in the connection between the treadles and the distant signals. During the snowfalls of Nov. 16, 17 and 24 of last year, the treadles could not be moved into position. The consequence was that the indications of the signals became uncertain and dangerous. In order to make the operation of the signals possible, it became necessary to disconnect the treadles. It seems at the very least very doubtful whether it is possible to improve the treadles in such a way that they will always act reliably, especially under unfavorable conditions in winter.

For this reason the experiments are to be continued in a modified form; instead of using movable treadles, having a position dependent on that of the distant signal, fixed treadles or bars are to be tried. The locomotive driver is then informed, not how the distant signal is set, but only that he is approaching such a signal, just as in the case of the electric apparatus described above. Experiments with this arrangement have not yet been made.

The proposal to use wireless telegraphy for transmitting signals to the locomotive has also been taken into consideration. The Stettin directorate has made trials of this kind on the Angermünde-Neukünkendorf section. The installation was provided by the firm of C. Lorenz, of Berlin; electro-magnetic waves, which were continually produced at a sending station, were transmitted by induction to the telegraph lines along the track, and from them to a receiver placed on the locomotive. At those places where an approach to a signal was to be indicated, the waves going to the receiver on the locomotives were intercepted by a screen. This brought a wave-detector back to the zero position and a colored disk was shown.

The experiments have shown that is is possible, within certain limits, to transmit signals to the locomotive; the strength of the waves, however, became materially reduced as the distance between the sending station and the locomotive increased. Then also the effect which the screen at the distant signal was intended to produce, was also produced in another way, for instance by telegraph lines crossing the railway, by iron bridges, by iron signal poles, and even when the locomotive ran through a deeper cutting. It is as yet hardly likely that this apparatus will give useful results.

On the other hand, good results were obtained with another device tried, the so-called recording alarm. This apparatus is intended to record the over-running of signals. A rail contact is placed next the home or block signal. If this is run over while the signal is at "danger," a recording alarm is set ringing at the place from which the signal is operated. In stopping the alarm a counter is advanced one, and thus records the over-running of the signal. This makes it possible forthwith to investigate every case of over-running. If a signal is over-run at all frequently, the cause can be investigated and any existing unfavorable conditions can be remedied. This apparatus has been tried by five different directorates, and in each case good results were obtained. A larger number of these recording alarms have accordingly already been ordered.

Thus the number of experiments made on the Prussian State Railway in order to determine, in actual practice, the utility of the proposed devices, is by no means inconsiderable. Proposals of the most varying kinds have been considered. Probably no other administration has made more systematic and comprehensive experiments in order to solve the problem of the prevention of over-running; and if, without prejudice, we consider the results of the experiments, we obtain an answer to the question why the administration of the Prussian State Railway has not yet decided on the general introduction of one of the proposed devices.

An "absolutely reliable" action cannot be demanded of such appliances, and will probably never be expected.

But it may with justice be demanded that failures shall be the exception, when that care is exercised in the maintenance of the track appliances and the rolling stock which is to be expected in a railway system of the magnitude of the Prussian State Railway.

But this standard has not yet been attained in the case of any of the appliances in question; nor, as may be specially emphasized, has it been attained in the case of the van Braam apparatus. Certainly the method adopted by the Prussian State Railway (practical trial of a large number of different appliances) is the best for finding out which of the appliances in question will satisfy all reasonable requirements.

In adopting this procedure, the administration need have no fear that it will lag behind foreign administrations in the utilization of valuable inventions; this is shown by the second report, just published, of the American Block Signal and Train Control Board, which was instituted in 1907 in order to test block signals, automatic stop signals and signals shown on the locomotive. The work of this board extended over two years, and during this time several hundred inventions were submitted to and examined by them. The result was that at the end of the second year of the period the report applies to, one sole appliance for stopping the trains from the track had been constructed and was ready for being tested in practice.

Thus this report shows that the large majority of the railway-signal engineers of the United States consider the question of the automatic rail contacts and signals on the locomotive as not yet sufficiently advanced to consider these appliances as ready for practical service. The same is indeed at present the case in Germany.

It is, however, to be hoped that the meeting of representatives of the German railway administrations, presided over by the German Railway Ministry, which is again going to discuss the measures to be taken for preventing the over-running of signals, will result in elucidating some of the points which are as yet doubtful, and that it will then be possible to make a material advance. The experiments made in Prussia form a valuable basis for the purpose. They are being continued and extended to any other proposals from which useful results may be expected.

That this will be the case with the inventions of the Unverricht Syndicate, which have been much talked about of late, is however open to doubt. The appliance used in connection with the Unverricht train-safety apparatus, for preventing the over-running of stop signals, consists of a fragile rod which is broken if a signal standing at "danger" is over-run, and this then makes the compressed-air brake act; similar devices have already been tried on the Prussian State Railway and found unsuitable for standard-gage tracks run over at high speeds.

In addition, with the Unverricht apparatus the running train automatically protects itself. It would therefore, like all similar appliances, have the disadvantage that if there was any failure in the apparatus it would be necessary, without special orders, to run past the block signal which is standing at "danger" and thus the stop signal would lose its significance as an absolutely prohibitive signal. In the case of a train-break, if the front part of the train continues its journey, the section behind the part torn off is opened without further ado. Thus there is the risk of another train running into the part torn off.

The automatic protection of the train is thus inferior, as regards the safety of the traffic, to the alternating-current section blocking, operated by the signalmen, as practiced on the Prussian State Railway; in this the opening of the section, and consequently the movement of the next train, is made dependent on the action of the train.

Of the 15,800 kilometers (9,820 miles) of double track and multiple track sections of the Prussian-Hessian State Railway, already 14,500 kilometers (9,010 miles) are equipped with this section-blocking. It will take about two years to equip the 1,300 kilometers (810 miles) left. Of the more important single-track sections, 1,500 kilometers (930 miles) are already equipped with section-blocking; the rest will be equipped during the next few years. Hence the system of automatic train-protection, on which the Unverricht invention is based, does not require consideration on the Prussian State Railway.

Dams, Barrages and Weirs on Porous Foundations.

By W. G. BLIGH,* M. Inst. C. E.

Structures of all descriptions are usually founded on an impervious stratum consisting of clay or solid rock; sand, on the other hand, in addition to being porous is easily disintegrated, the particles of which the mass is composed having no mutual cohesion; consequently in the case of hydraulic works which are subjected to hydrostatic pressure, sand would seem to be an absolutely unsuitable material for foundations. In spite of these apparently insuperable defects it is quite possible to design works of assured permanency on nothing but this proverbially unstable material for a foundation. The most notable hydraulic works of this description are the diversion weirs and open dams across great rivers whose beds consist of sand of practically unlimited depth. Of such the Colorado weir of the Yuma irrigation project may be cited as an example in this country. To found these structures on solid clay or rock would involve continuous foundations below the river bed of a depth of 50 or 100 ft. or more, which is clearly impracticable, consequently the work has perforce to be founded on the sandy bed itself.

These works are not only subject to hydrostatic pressure, which tends to undermine the structure by gradual disintegration and removal of the porous substratum, but owing to the obstruction offered to the free passage of floods, they are further exposed to the kinetic effect of masses of water in violent motion. Notwithstanding this many large works of like description have been successfully constructed and are as stable and permanent as if on solid rock instead of on the ever shifting sand of deep rivers.

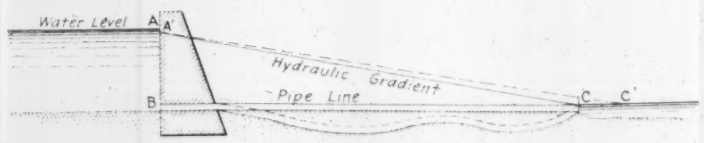


Fig. 1.

The object of this paper is to explain the principles underlying the successful design of hydraulic works founded on a loose porous foundation of sand, gravel, or boulders, and further to deduce rules for their application to practice.

All formulas or rules for the dimensions of parts of structures must be originally deduced from actual experiment. In the case of river diversion weirs the failures of some of these works form valuable object lessons, which are equivalent to experiments in a large scale. It is by deduction from the facts obtained from these failures under stress, which latter are closely analogous to the fracture of beams or rods tested to their utmost endurance, that reliable rules can be framed whereby any structure on a porous foundation can be designed with perfect confidence as to its stability.

Fig. 1 illustrates the case of a pipe line leading out of a reservoir of water. As is well known the velocity of the current confined in a pipe of one size is uniform throughout and varies directly with the pressure, that is with the head of water, and inversely with its length. A line A' C joining a point A' somewhat lower than A, the actual water level in the reservoir (to allow for loss of head due to entry) with the level of the water where the pipe terminates and discharges its contents into the open, is termed the Hydraulic Gradient and ordinates drawn from the center of the pipe to this grade line measure the head acting at the several points.

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The pressure, or its equivalent the head, thus diminishes regularly from the entry to the termination of the pipe line where it vanishes. If the pipe line were not straight but sinuous, the Hydraulic Gradient would be A' C', B C' being the length when straightened out.

Fig. 2 illustrates the case of an impervious earthen embankment overlying a porous sand stratum holding water on one side. The hydrostatic status in this case is in no wise different to that already shown as obtaining in the pipe line. The pressure of the water in the reservoir under the head A B causes percolation through the porous sand, lying below the impervious base of the earthen dam, from the point B to C. At this latter point the confinement below the superimposed mass ceases and the percolating water is free to rise, consequently the upward hydrostatic pressure comes to an end and the hydraulic gradient as before is the line A C, the hydrostatic upward pressure being measured by vertical ordinates from B C to A C and the total by the triangle A B C. This upward pressure is counterbalanced by the weight of the earth plus that of the water overlying the near slope.

As in the case previously considered, the water in its passage through the particles of sand forming the foundation, acquires a uniform velocity which is proportional to the length of this enforced percolation, and the hydrostatic pressure, as measured by the head, is also gradually neutralized. This neutralization of head, as in the pipe line, is produced by the friction encountered by the slowly percolating current in its travel through the sand and the resulting retardation of flow must also vary with the fineness or coarseness of the medium through which the percolation takes place. The safety of a structure subjected to water pressure and founded on a porous stratum from being undermined by a gradual process of washing out of the particles of sand by the percolating under current—termed piping—is thus clearly dependent on the length of the enforced percolation provided. If this length, which will be symbolized by the letter l, is made sufficient to reduce the velocity of the flow of the under current to such a proportion as it will exercise no deleterious effect as regards disintegration of the sand, it is evident that the safety of the structure from failure due to "piping" will be assured.

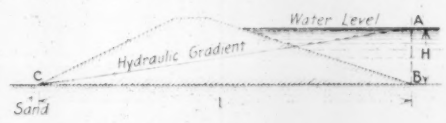

Fig. 2.

The value to be assigned to l must clearly be some multiple, c of the head H or $l = c\ H$.

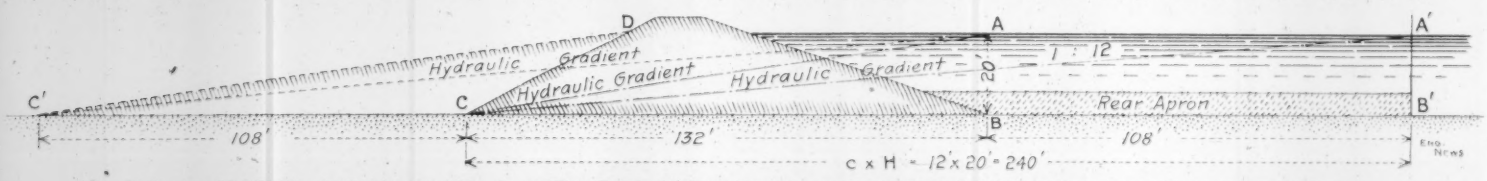

FIG. 3. SECTION SHOWN IN FIG. 2, WITH TWO METHODS OF CARING FOR PERCOLATION THROUGH FOUNDATION.

(Rear apron on right; extension of fore wall on left.)

The problem thus resolves itself into the simple one of finding reliable values for this so-called "percolation factor" or coefficient c, suitable to different classes of sand. These can only be deduced from actual experience. In the accompanying table, sands have been roughly classified and suitable percolation factors, based on experimental statistics or deduction from such, have been assigned to them, as will be subsequently explained.

VALUES OF PERCOLATION FACTOR c IN EXPRESSION $l = c\ H$.

	Class.	c.
Fine silt and sand as in Nile River	A	18
Fine micaceous sand as in Colorado and Himalayan Rivers	B	15
Ordinary coarse sand	C	12
Gravel and sand	D	9
Boulders, gravel and sand	E	4 to 6

In Fig. 3, suppose the length of enforced percolation B C, to be insufficient and the hydraulic gradient A C too steep, the velocity of the percolating water will be capable of conveying away

particles of sand from beneath the earthen dam and thus undermining it. Assuming the sand in this case to be of Class C it will have a percolation factor of 12, and with $H = 20$ ft., then the required base length will be $12 \times 20 = 240$ ft., the actual base length being 132 ft. only. In order to increase the value of l, two courses are open: The first is to lengthen the base width of the embankment down-stream. In order to effect this the whole embankment would have to be enlarged, as shown in the dotted outline to the left, so as to meet the increased upward hydrostatic pressure. A second method whereby this enlargement in section can be avoided is to lengthen the impervious base rearward. In this case the upward hydrostatic pressure to the rear of the dam is more than balanced by the overlying weight of water, consequently a comparatively thin impervious apron of earth is all that is required. This is shown at the right of Fig. 3. The resulting effect of this "rear apron" as it is termed is to throw the incidence of the head backward from A B to A' B'. The length B' C will be 240 ft. and the hydraulic grade line A' C will be 1 in 12.

Theoretically the rear apron need not be anything but an impervious sheet of material, but practically it must be of some definite weight, as otherwise the percolation might partake of the nature of a surface current beneath the apron and would not be forced to pass through the medium of the sand, for which reason the rear apron, if of clay, is usually made not less than 4 or 5 ft. thick.

In the case of embankments built across running streams carrying silt in suspension, an efficient natural rear apron is often formed by deposit; this, however, should not be depended upon, since if a watertight connection is not formed with the embankment, or if a break occurs in the continuity of the apron, the incidence of the head will not be at the termination of A', but at some intermediate point, and so the effective length of percolation will be reduced below what is the safe limit.

In addition to the extension of the base fore and aft of the original embankment, there is yet another means available whereby the travel of the percolation can be increased and that is by extension in a vertical direction. This is exemplified in Fig. 4, where at the base of the embankment a row of sheet piling or some such other impervious curtain wall is inserted. It has been ascertained experimentally that the value in increase of length of percolation due to a vertical obstruction is double that beneath a horizontal apron, for the reason that the percolating current travels down one side of the obstructing curtain wall and up the other. This is subject to the proviso that vertical curtain walls, if more than one, are not spaced nearer than twice their depth.

In Fig. 4 the depth of the curtain is made equal to c, or 12 ft., and the rear apron is reduced by 24 ft., or by $2c$, the length of percolation remaining the same as before. The hydraulic grade line A C will, however, not be in one continuous line but will have a step at the vertical curtain, the depth of which will be equal to the neutralization of head effected by the curtain. As the latter is made 12 ft. in depth the neutralization thus effected will be equivalent to 2 ft. depth of water.

The case of a diversion weir across a river will now be considered. Such a structure consists of two main parts, the weir or drop wall, which is usually provided with collapsible iron crest shutters, and the apron. As the height of the obstructing weir seldom exceeds much above 10 ft. except on a boulder bed, the weir wall itself in a direct overfall is of minor consequence, the design being mainly centered on that of the apron.

Fig. 6. illustrates the case of a direct overfall weir, provided with crest shutters and with a horizontal fore apron. This latter adjunct is obligatory apart from hydrostatical reasons, for the protection of the bed from the scouring action of the water passing over the weir. The width of this part of the impervious apron must therefore be of a fixed minimum value W, which is obtained by the following empirical formula based on actual practice,

$$W = 4\,c\sqrt{\frac{H_1}{13}}$$

in which H_1 is the height of shutter crest above the floor level or A B

The width of the fore apron, obtained by the above formula is in terms of the percolating factor, a reasonable deduction, as the value of c is representative of the nature of the river sand. The lighter the sand the easier disintegrated, consequently a longer apron will be required. The formula is based on the hypothesis that with a 10-ft. over-fall and 3-ft. deep-crest shutters, as is the case with the existing work illustrated in Fig. 11, the correct length for the fore apron will be $4c$, or in this case $4 \times 15 = 60$ ft. When the height of the shutter crest is more or less than 13 ft., the width of the apron will vary in proportion to the square root of such height with that of the standard, which is 13 ft.

toe of this talus, measured from the drop wall, is dependent on two considerations—first, the height of the permanent obstruction H_2, or that of the masonry drop wall above low water (A' B in Fig. 6), and secondly, on the intensity of the action of the river in flood, which can be gaged by the unit flood discharge over the weir, symbolized by q. Taking the Narora Weir, Fig. 10, as model, the width of the talus, or L, will vary as $\sqrt{H_2}$, i. e., $\sqrt{10}$, and also as $\sqrt{q}$, i. e., $\sqrt{75}$. The formula will then be

$$L = 10\,c\sqrt{\frac{H_2}{10}} \times \sqrt{\frac{q}{75}}$$

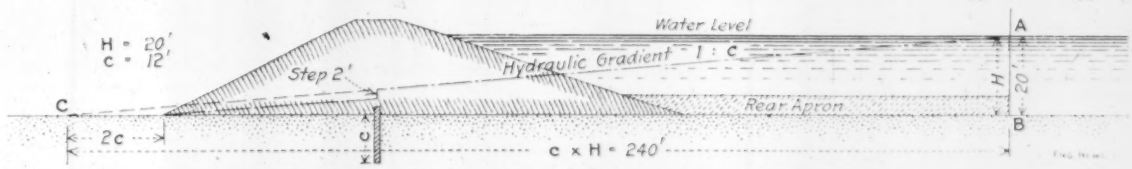

FIG. 4. ADDITIONAL PROTECTION BY CURTAIN WALL.

Thus supposing the drop to be 12 ft. and the sand of Class C and the unit flood discharge, or q to be 150 sec.-ft.

Then the width of fore apron will be

$$W = 4\,c\sqrt{\frac{H_1}{13}} = 4 \times 12 \times \sqrt{\frac{12}{13}} = 48 \text{ ft. or } 4\,c$$

nearly.

The distance of the talus from the drop wall, or L, will be

$$10 \times 12\sqrt{\frac{12}{10}}\sqrt{2} = 185 \text{ ft.}$$

With a 40-ft. high weir, on a boulder bed, having a percolating factor of 5 and q assumed at 215 sec.-ft., $W = 35$ ft. and $L = 173$ ft.

The length of impervious apron obtained from the width W, plus the base width of the drop wall being never sufficient for the purpose of percolation, the required value of l or of $C \times H$ will have to be made up by the addition of a rear apron, or by that of a vertical curtain as well.

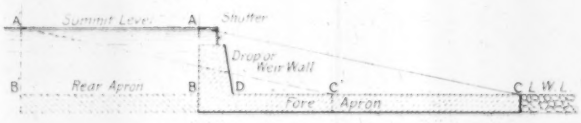

Fig. 5. Typical Overflow Weir Section.

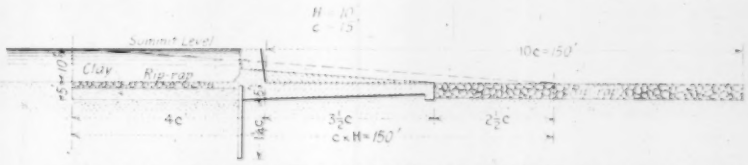

FIG. 6. OVERFLOW WEIR SECTION PROTECTED BY APRON AND CURTAIN WALL.

In Fig. 6, suppose B C to be the proper length of percolation, i. e., equal to $c \times H$; then the hydraulic gradient will be A C and the area A B C will represent the head acting on the floor B C. If the distance D C', measured from the toe of the drop wall, be made equal to the minimum length of apron, or

$$4\,c\sqrt{\frac{H_1}{13}}$$

it is clearly of advantage to stop the fore apron short at this point and make up the required length of enforced percolation by inserting the rear apron B B', the length D B' being made equal to C' C. The incidence of the head of water is then thrown back from A to A'. This arrangement substitutes a length of inexpensive clay apron for one of solid masonry and further as is shown by the area A' B' C', the hydraulic lifting pressure on the drop wall and fore apron is very largely reduced.

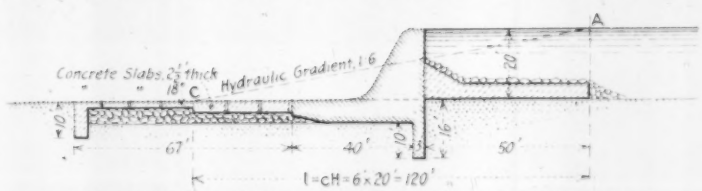

FIG. 7. GRANITE REEF WEIR, SALT RIVER PROJECT, U. S. RECLAMATION SERVICE, AS BUILT.

Beyond this impervious solid apron, a continuation of riprap is necessary. The width of the

As 1 ft. of head is neutralized in every length equal to the percolation factor c, it is convenient to have all longitudinal dimensions of the apron multiples of c.

A design of a section under the actual conditions of head and river sand existing at Narora, Fig. 10, excluding the weir crest shutters, is exemplified in Fig. 7. The width of the fore apron will be

$$4\,c\sqrt{\frac{10}{13}} = 3\tfrac{1}{2}\,C \text{ nearly.}$$

and the total required value of l being $10c$, or 150 ft., the difference of $6\frac{1}{2}c$ is made up by assigning $4c$ to the rear apron and $2\frac{1}{2}c$ to the vertical curtain, which distribution is variable at pleasure.

The thickness t of the fore apron must be such that the effective weight exceeds that of the upward hydrostatic pressure. The weight can be represented by the thickness multiplied by the specific gravity or by $t \times \rho$. At the same time the opposing hydrostatic pressure is represented by $(H - h)$, $h = l/c$ being the head neutralized up to the point in question. In both expressions w, the unit weight of water, is omitted as a common factor; thus pressure is represented by the head and weight by thickness × specific gravity. When the apron is immersed below low water

its weight will be represented not by $t\ \rho$ but by $t\ (\rho - 1)$.

The weight should, it is considered be one-third in excess of actual requirements and the thickness will then be

$$t = \frac{4}{3}\ \frac{H-h}{\rho-1}.$$

In Fig. 7 the value of $H - h$, at the toe of the drop wall, where the fore apron commences, is $10 - 6\frac{1}{2} = 3\frac{1}{2}$ ft., and assuming a value for ρ of 2, the thickness will be $\frac{4}{3} \times \frac{3\frac{1}{2}}{1} = 4\frac{2}{3}$ ft.

The profile of the fore apron should be trapezoidal in outline, tapering towards the end, so as to correspond in some measure with the progressive diminution of the water pressure. The end thickness will be made 3 ft., which is about a minimum. The hydrostatic pressure area is shown hatched above the floor line. The rear apron is made 5 ft. thick, following precedent, and is composed of wet clay overlaid by riprap. The talus of riprap is made 4 ft. thick; in many cases in actual practice its thickness is 5 ft.

It may be noted here that any extension of the impervious fore apron beyond the actual necessities of the case is to be deprecated as increasing the hydrostatic pressure on the work.

Where a boulder bed is concerned the fore apron can be made pervious by leaving spaces between the blocks of concrete of which the floor can be built. This, however, will necessitate a corresponding increase in the length of the rear apron to compensate for the reduction in the effective length of enforced percolation, so that it is of doubtful utility. With a sand foundation such a construction would not be practicable, as the sand would be carried through the open spaces and the floor undermined.

ference of level of the permanent weir crest above low water level, which is not affected by the relative height of the floor. Most weir crests are provided with collapsible crest shutters now often made of considerable depth from 3 to 6 ft. This enables the permanent weir crest to be kept low and thus offer much less obstruction to floods. The shutters increase the statical head, the maximum being at a time when the up-stream water is at shutter crest level, the down-stream channel being empty. In Fig. 7, if 3-ft. shutters were adopted, the value of l would be increased from $10c$ to $13c$, or to $13 \times 15 = 195$ ft. This would involve longer fore and rear aprons and deeper curtain walls or a second vertical curtain could be provided at the termination of the apron.

A step would then occur in the water pressure outline at the end, demonstrating a corresponding increase in the hydrostatic pressure on the floor throughout. The terminal curtain is

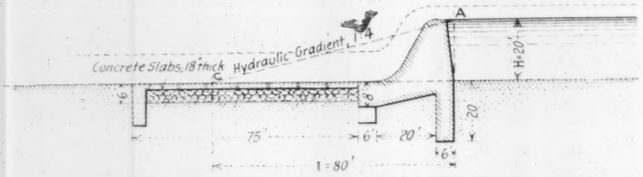

FIG. 8. GRANITE REEF WEIR AS PROPOSED BY MR. BLIGH.

more required for protective purposes in case of failure of the talus, for which purpose it could well be made pervious, so as not to affect the hydrostatic status behind it.

Fig. 10 is a section of the Narrora weir on the Ganges River (the failure of which forms so valuable a lesson) as originally constructed. The hydraulic gradient works out to 1 in 11, or probably steeper owing to the fore curtain, composed of circular undersunk wells connected with piling, not being absolutely impervious. At this gradient the work stood for 20 years, but was always in a state of unstable equilibrium. The hydrostatic pressure area shows a great deficiency in the area of the floor, which must have

as is proved in both this and the previous case may last for some years before failure actually takes place. The renewal was on the same lines as before, viz., by extension of the rear apron. The hydraulic gradient, on failure, was as low as 1 in 8.3 and the present value is 1 in 16. Other instances can be cited in corroboration of the fact that the percolation factor of this class of light sand cannot be of less value than that of 15, which is adopted. Having assigned this value for Class B, that of Class C is placed at 12, while that of Class A is at 18. The correctness of latter value is attested by several examples of Egyptian works.

Fig. 12 illustrates the apron built for strengthening the old Nile Delta Barrage, or open dam. By means of this rear apron and the cement grouting, under pressure, of the old floor, the barrage was enabled to uphold a head of 14 ft. of water, whereas previous to the construction of the apron the work was quite incapable of any service, and was useless for the very purpose for which it had been designed.

The value of l in Fig. 12, is horizontal, 238, vertical, 50, total 288 ft., the percolation factor will therefore be $288 \div 14$, or 20 nearly.

In the Zifta Regulator, Fig. 13, the horizontal component is 45.50 meters and the vertical, including everything, 21 meters, giving a total of 65.50 meters. The head being 4 meters, the value of c will work out to be $65.50 \div 4 = 16.4$.

In the Assiut Regulator, the horizontal component of the length of enforced percolation is 51.50 meters, the vertical 22 meters, total 73.50; with a head of $3\frac{1}{2}$ meters the value of c will then be 21. In designing the older works it is probable that the thickness or depth of the foundation, situated above the sheet piling, was not included in the count as it strictly should be; if this item were omitted, the value of c in this case would be reduced to very near that of 18, which has been adopted for this class of sand.

Several instances can also be adduced in support of the value of 12, adopted for ordinary coarse sand. As regards boulders and boulders

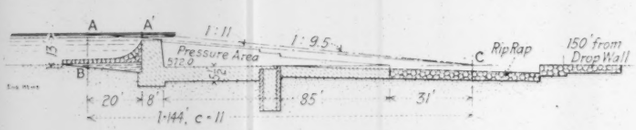

FIG. 9. NARRORA WEIR AS ORIGINALLY BUILT.

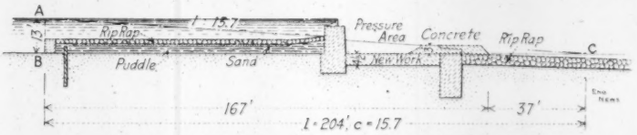

FIG. 10. NARRORA WEIR AS RECONSTRUCTED.

An open floor as described was constructed in connection with the Granite Reef weir (Fig. 8) over the Salt River, already noted in Engineering News,* although it is considered that this design could be improved upon by adopting a clay rear apron and thickening the blocks of the floor from $1\frac{1}{2}$ to $2\frac{1}{2}$ ft., and lengthening the latter; this will admit of the profile of the weir wall being reduced. The hydraulic gradient in this alternative section (Fig. 9) is increased to 1 in 6, originally it is about 1 in 4.

The value of the rear apron as an inexpensive means of reducing hydrostatic pressure on the weir wall and its floor and also of providing length of enforced percolation is now fully recog-

been in a high state of tension. Shortly before the final catastrophe, borings revealed the fact that the floor was then entirely undermined and was only held up or supported against collapse by the hydrostatic pressure.

After a heavy freshet in the river in which the rear apron was washed clean out, the hydraulic gradient fell to 1 in 9.5, and the whole floor was blown up.

The repairs, shown in Fig. 11, consisted first in the lengthening of the rear apron to 80 ft.; the weir floor was built somewhat thinner and of heavier material and was further strengthened by a mass of concrete above the original floor level. The length of the impervious fore

mixed with gravel and sand, there are no examples of failures and the values assigned will vary from 9 to 4, the example of the Salt River weir (Fig. 8) forming a valuable precedent.

In the above given examples, the head, symbolized by H, always represents the difference of levels above and below the work. When the fore apron is immersed below low water level, the part thus affected is considered to have lost weight or specific gravity, its weight will therefore be represented by $t \times (\rho - 1)$ and not by $t \times \rho$. When the foundation of the apron lies above low water level, the external head causing hydrostatic pressure on the base will be less than H, since, owing to the porosity of the sub-

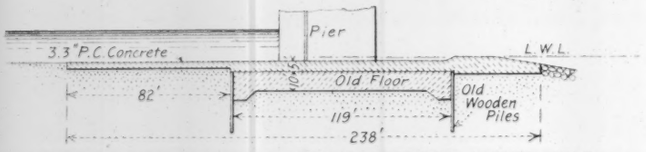

FIG. 11. FOUNDATION OF GRAND BARRAGE, LOWER NILE.

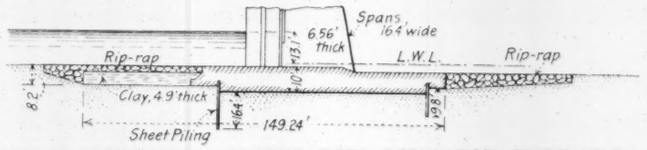

FIG. 12. FOUNDATION OF THE ZIFTA REGULATOR, RIVER NILE.

nized, and all recent weirs on porous foundations are provided with rear aprons.

In some overfall weirs the fore apron is raised above low water level in order to avoid wet construction; the talus then will slope down to that level or to below it. In these cases the width of the apron will be less than before, H_1 in the formula being the height of shutter crest above the floor, that of the talus will, however, be unaltered as in that formula H_2 represents the dif-

apron was reduced below what it was originally in Fig. 10. The value of the percolation factor, c, is increased in the renewed section from 9.5 to 15.7, at which the safety of the work is assured.

A further object lesson is provided by the Chenab River weir built on the same class of sand as the previous example. After existing in a state of insecurity for some years, the floor finally collapsed by undermining. This undermining by "piping" is a gradual process, and

stratum, the water will rise up to the impervious base. The weight of the apron will in this case be unimpaired by flotation and will be represented by $t \times \rho$. The required length of travel of percolation, however, cannot be reduced below $c\ H$, which length must be provided irrespective of the level of the impervious floor.

There further exists a large class of weirs composed almost entirely of porous rock fill which will require separate investigation.

*Oct. 1 1908, p. 366; Jan. 7, 1909, p. 1.

An Automatic Sluice Gate to Ensure Constant Water Level.

By E. LAUCHLI.*

In Europe there has been in operation for some time a type of automatic dam or sluice gate which on account of its simplicity of construction, adaptability to existing structures, exact mathematical treatment, and especially its successful operation, deserves to attract the attention of the hydraulic engineer connected with the design of hydro-electric plants or irrigation works. Fig. 1 shows a cross-section and front elevation of one of the above mentioned dams now in course of construction, and the view in Fig. 2 gives an idea of a small automatic dam of the same type which has been in successful operation for several seasons, including a severe winter, and during high spring floods.

Briefly stated, the automatic dam is composed of a movable part or panel, resting at the bottom on a knife edge, and fastened at the top to a compensating roller made of steel plate and filled with concrete. This roller moves along a track located at each of its ends, and is so designed as to take, at any height of water upstream, a position such as will give the apron the inclination necessary for discharging a known amount of water, and in so doing will keep the upper pool at a constant fixed elevation.

With the roller at its highest position the panel lies horizontally, and the full section is then available for discharging water. Any debris, such as trees, or ice cakes, etc., will pass over the dam without any difficulty, even during excessive floods, as the compensating roller is located high above extreme flood level.

The dam now in course of construction is located on the river Grafenauer Ohe, in Bavaria, and will regulate the water level at the intake of a paper mill, located at some distance from the powerhouse. The dam has a panel 24.27 ft. long, 6.85 ft. high and during normal water level will discharge 1,400 cu. ft. per sec., while at flood time it will pass 3,530 cu. ft. per sec. of water. As shown in Fig. 1, the main body of the dam is made of a wooden plank construction laid on a steel frame. The panel is connected with the compensating roller at each end by a flexible steel cable wound around the roller end, and then fastened at the upper part of the roller track to an eyebolt. A simple form of roof construction protects the roller track from rain and snow. The panel is made watertight at each extremity by means of galvanized sheet iron held tight against the abutments by water pressure. This type of construction has so far proved to be very effective as to watertightness.

It may be needless to point out that this type of dam can also be fitted to the crest of overflow dam of ordinary cross-section, and then fulfill the duty of movable flashboards.

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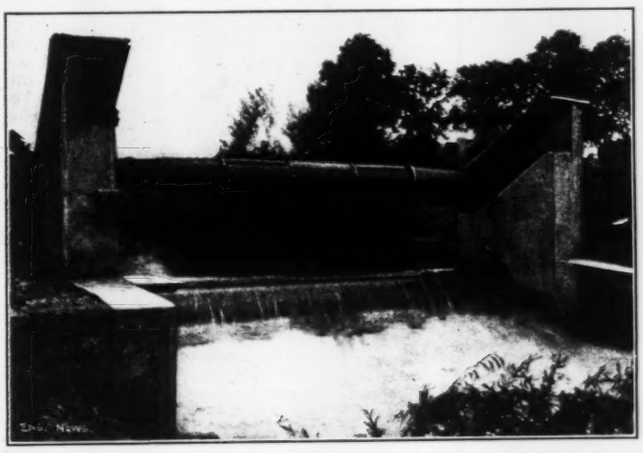

FIG. 1. DETAILS OF AUTOMATIC DAM ON GRAFENAUER OHE RIVER, BAVARIA.

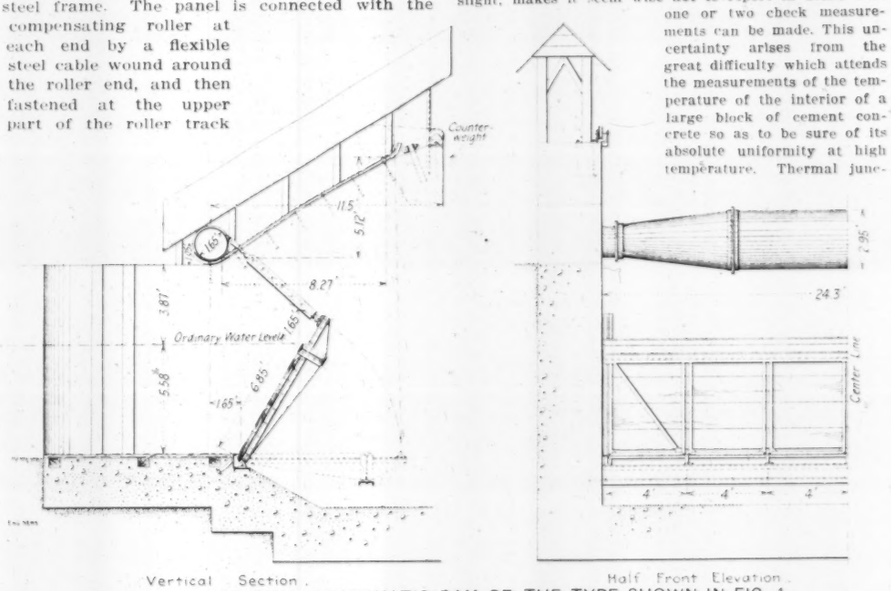

FIG. 2. VIEW OF SMALL AUTOMATIC DAM OF THE TYPE SHOWN IN FIG. 1.

Some Thermal Properties of Concrete.*

By CHARLES L. NORTON.†

During the last three years a series of experiments have been carried on in the Laboratory of Heat Measurements of the Massachusetts Institute of Technology, having for their object the study of those physical properties of Portland cement concrete which affect its value as a fire resistant material. While these researches are by no means complete, it is perhaps of interest at this time to discuss some of the results obtained.

It was proposed at the outset to make a study of the various physical properties of concrete over as wide range of temperatures as possible, and among those selected were the following:

1. Coefficient of linear expansion.
2. Diminution of mechanical strength after heating.
3. Specific heat.
4. The coefficient of thermal conductivity.

The measurements of the coefficient of linear expansion are practically complete, but the uncertainty attaching to some of the high temperature values, though slight, makes it seem wise not to report in detail until one or two check measurements can be made. This uncertainty arises from the great difficulty which attends the measurements of the temperature of the interior of a large block of cement concrete so as to be sure of its absolute uniformity at high temperature. Thermal junctions embedded in the block at distances of three inches from one another are not sufficiently close to give the desired precision.

The method adopted for the measurements of the elongation caused by heating was the common so-called "telescope" method. The specimens in the shape of 6-in. or 10-in. cubes were slowly heated in a double gas muffle or an electric resistance furnace. The temperature of the furnace and of a number of points in the concrete was taken by means of platinum-rhodium couples.

Near the furnace were mounted two telescopes which might be sighted through holes in the furnace wall upon reference points on the surface of the block. At low temperatures an arc light and a system of mirrors were used to furnish adequate illumination. One of the telescopes was provided with a micrometer eye piece by means of which a movement of the reference mark of .001-in. could be measured.

The values obtained at low temperatures agree very well with the commonly accepted value of 0.0000055 for the elongation per unit of length per degree Fahrenheit. Apparently this value increases slightly up to 575° F. Above this point the coefficient becomes smaller; at 1,500° F. the coefficient becomes zero, and above this point slightly negative. On cooling the blocks which had been heated to 1,500° they did not return to their original dimension, their permanent elongation being about 75% of their maximum elongation. On a second heating the specimens all returned to the same dimensions, there being no sensible permanent elongation resulting from the second heating.

All of the specimens tested for expansion were of stone concrete, of the proportions 1 : 2 : 5. The stone was clean, the sand sharp, the cement of good quality, and every precaution was taken to secure a concrete of the first order. The specimens weighed on the average 150 lbs. per cu. ft.

In order to study the effect of high temperatures upon the compression strength of concrete several scores of 6-in. cubes were made and allowed to set for 90 days or slightly longer. These blocks were then heated for different lengths of time at different temperatures in a gas furnace similar to that used for the expansion experiments.

The cubes which were not heated showed an average compression strength of 2,700 lbs. per sq. in. Those which were heated to 932° for two hours lost only 15% of their original strength, and when this temperature was prolonged for four hours the loss was 43%. If the blocks were heated to 1,500° for two hours the loss of compressive strength was 38% and at the end of four hours the loss was 66%. The most important information secured from these tests was to the effect that even after exposure to a fire in which the concrete block, small in size, was subjected to flames at a temperature of 1,500° for two hours, it was still able to carry twice its normal safe load in compression. The larger beams with their great masses are not often exposed for so long a time to so great a hazard.

It should be noted, however, that there was a considerably greater deformation under load of the heated blocks than of those not heated.

A large number of small beams were next made, some with and some without reinforcement; most of these were either 6 × 6 × 48 ins. or 8 × 8 × 48 ins. The specimens which were reinforced contained four ½-in. round steel rods situated near the corners, equidistant from the two faces of the beam. In some the distance from the steel to the face of the beam was 1 in. In others 1½ ins., and a few beams had a 2-in. protection to the steel. Not many of these specimens have been tested as yet, but, from a few, we are able to get a general idea of what happens to beams of this type in case of exposure to fire.

A set of three beams for instance, each 6 × 6 × 48 ins., in which the reinforcing rods were 1-in. from the face of the beams were broken by center load, the first beam not having been heated at all, the second heated for one hour in a fire that fused the surface of the concrete, and the third being similarly heated for two hours. The beam which was not heated broke under a load of 5,700 lbs.; the second, heated for one hour, broke at 2,750 lbs., while the third, heated for two hours, broke at 1,950 lbs. It should be borne in mind that these small beams were so slow in cooling down that they were in effect heated much longer than the time mentioned. The flames, moreover, surrounded the beams on all sides.

Several similar tests were made with concrete beams of the same dimensions, 6 × 6 × 48 ins., with no reinforcement. These were heated for two and four hours at 1,700° F. After this exposure all of the beams were very frail, not one of them showed any cracking or spalling, however. It was not considered necessary to break any of these beams, as it was apparent that the concrete on the tension side of the beam was much weakened. Some of the more recent experiments made on beams 8 × 8 × 48 ins. show that these larger beams are much less weakened, proportionally, as would be expected to be the case.

*Paper presented to the Annual Convention of the National Association of Cement Users, N. Y., Dec. 12-17, 1910.

†Associate Professor of Heat Measurement, Massachusetts Institute of Technology, Boston, Mass.

A series of similar beams were next made up of cinder concrete, the proportions of the mixture being 1:2:5. A portion of these were mixed with clean cinders, which showed upon analysis but little carbon; a second part was mixed with cinders to which 10% of fine bituminous coal had been added and the other beams were mixed with cinder to which had been added 25% of fine coal. The 25% mixture can be disposed of in a word. When once thoroughly heated it burned until it fell to pieces. With the 10% mixture, however, no such action occurred; there was no indication that the concrete would support its own combustion even for a short time. It was apparent that the 10% mixture was not so good a fire-resisting material as that which contained no added carbon. From the few specimens containing less than 10% which have been examined up to the present, it seems probable that the safe limit is close to 5%. More data are now being secured on this point.

The study of the specific heat of concrete was made by the ordinary calorimeter method, the "method of mixtures" of Regnault. Specimens of the concrete, usually fragments of the larger test pieces, were heated slowly in an electric resistance furnace to the desired temperature and then plunged into the calorimeter. The weight of the water and its rise in temperature give the amount of heat given off by the body in cooling.

Extraordinary precautions were taken in getting the exact average temperature of the specimen in the furnace, and to ensure its rapid transfer to other calorimeter. In most of the experiments a double calorimeter was used so that the specimen did not come in contact with the water of the calorimeter, so that any evolution of heat by hydration of the cement was avoided. The following table gives the specific heat of concrete:

SPECIFIC HEAT.

Temperature.	Stone concrete. 1:2:5	Stone concrete. 1:2:4	Cinder concrete. 1:2:4
72° to 212°	0.156	0.154	.....
72° to 372°	0.192	0.190	0.180
72° to 1,172°	0.201	0.210	0.206
72° to 1,472°	0.219	0.214	0.218
72° to 2,172°	.....	.....	.....

The measurements of thermal conductivity were made by a number of methods and have taken far more time and energy than all the others put together. The thermal conductivity is that property which determines how rapidly heat will travel through a substance and how rapidly therefore objects beyond will be heated by transmission. The conductivity becomes of prime importance of all questions of protection of the steel in reinforced-concrete buildings. There are very few data to be found as to this important property of any of the common materials of engineering and such data as is to be found are not at all concordant. As to the conductivity of concrete or its variation with temperature and with composition, practically nothing has been known.

The methods adopted for the measurement will be described in full in papers now being submitted to one of the scientific societies for publication and it probably will not be of interest here to more than outline them.

The formula showing the relation of the temperature upon the two sides of a plate to the amount of heat which would flow through it is as follows:

$$Q = \frac{K\ (t_1 - t_2)\ s\ A}{d}$$

or

$$K = \frac{Q\ d}{(t_1 - t_2)\ A\ s}$$

where

K = the coefficient of thermal conductivity dependent upon the nature of the material and its temperature.
Q = the quantity of heat flowing through the plate in the area measured.
A = the area.
t_1 = the temperature of the hotter side of the plate.
t_2 = the temperature of the cooler side of the plate.
d = the thickness of the plate.
s = the time during which Q units flow through the area A.

The formula will be seen to be merely an expression of the following relations, that the flow of heat is proportional to the area, to the temperature, and the time, and that it is inversely proportional to the thickness.

After spending many months in developing other methods the electrical method used by the writer for the past 15 years in studying the flow of heat through steam pipe coverings was adopted. The value Q of the heat flowing was determined by supplying the heat by means of the heating of a conductor carrying a current of electricity. By measuring the electrical energy supplied the quantity of heat developed may be known with great precision. Further, if this heat is passed through the plate under test and into a calorimeter on the far side, a check upon the value Q may be had. For the determination of the temperature difference thermal couples, platiresistance thermometers, and mercury thermometers were used, but thermal junctions made of thin strips of copper and nickel or of platinum and platinum-rhodium were generally found most serviceable.

The apparatus used for the lower temperatures consisted of a thin, electrically-heated plate to the two sides and edges of which concrete could be applied. Outside of the concrete there was then placed heavy copper or brass plates which could be kept at a constant temperature by an internal circulation of water. Thermal junctions were placed at several points on each surface of each concrete plate. The electrical input was measured by calibrated Weston instruments, the calibrated thermal junctions gave the value of the temperature difference to the nearest one one-hundredth of a degree. For the thickness, numerous measurements were made by a pair of flat-nosed calipers and averaged.

It was necessary to keep this apparatus running for several days before it could be balanced, that is, before the rate of flow of heat outward through the plates became constant and equal to the electrical input. The number of measurements has now reached many hundreds, and it seems apparent that the precision of the method depends on the accuracy with which the thickness of the specimens can be maintained constant. Otherwise the accuracy is better than 1%. This apparatus has been named by my assistants the "flat-plate tester" and perhaps it is well to so designate it here.

Later, in order to make tests on plates as thick as some of the walls in common use, another method was adopted. Cubical boxes 36 ins. in outside dimension were built with walls of several thicknesses. Inside the boxes were placed electric heaters which served to raise the inside surface to a temperature above that of the surroundings. A small fan served to keep the air in the box stirred to insure uniformity of temperature throughout. The boxes were tightly sealed. The power supplied to both heater and fan was measured as before. Mercury thermometers and thermal junctions, as well as a Callender recording resistance thermometer were used to measure the difference in the temperatures inside and outside of the box. Data have been secured on scores of specimens and they are practically identical with the results obtained by the flat-plate tester.

For the high temperatures a modification of the entire process was found necessary. The concrete to be tested was cast in the form of a cylinder on the outer surface of and concentric with a steel bar which could be heated to a high temperature by the passage of a heavy current. Outside of the cylinder of concrete was applied a closely fitting "continuous" calorimeter. The temperature of the bar and of the calorimeter were measured by thermal junctions, and the amount of water and its rise in temperature gave the value of Q.

In order to guard against the uncertainty of the temperature at the ends of the bar, the calorimeter was made so as to enclose only about one-half the length of the bar, the rest being covered by guard rings similar to the calorimeter but without any provision for the measurement of the quantity of water.

The heating of the bars required a considerable amount of special apparatus, since it was necessary to provide a current of upwards of 2,000 amp. for the high temperatures, and to be able to vary its amount to any desired value below that point. For this purpose there were installed three 15-KW. transformers connected on the primary side with a three-phase, 2,300-volt circuit. By means of divided secondaries and a rather elaborate arrangement of switches, the secondary voltage could be varied from 190 volts down to 55 volts. This secondary voltage was applied to the primary of a second step-down transformer, whose secondary was divided into twenty coils. By means of a switchboard the entire output of the transformer could be had at almost any desired low voltage. This enables us to heat bars insulated by materials of different composition and of different thicknesses to any desired temperature up to 2,800° F. With this arrangement both the steel and the concrete can easily be melted.

The results obtained are tabulated below. It is to be regretted that there is no uniformity of practice as to the units to be adopted in reporting the measure of effectiveness of insulators. While the physicist renders his report in calories per square centimeter, per centimeter thickness, per 1° C. per second, the steam engineer confines his observations to B. T. U. per hour per sq. ft., per in. of thickness, per 1° F. and the refrigerating engineer reports on the basis of a 24-hour time unit. I have even seen a report in terms of hogsheads of water raised to the boiling point, time not stated.

THERMAL CONDUCTIVITY OF CONCRETE.

Temperature of hot side of plate C.	F.	Mixture.	Coefficient Calories per 1° C. per sq. cm. per cm. per sec.,	Coefficient B.T.U. per 1° F. per sq. ft. per in. thick per 24 h.
35°	95°	Stone 1:2:5	.00216	150.
50°	122°	Stone 1:2:4 not tamped	.00110 to .00160	76. to 114.
50°	95°	Cinder 1:2:4	.00081	56.
200°	392°	Stone 1:2:4	.0021	146.
400°	752°	Stone 1:2:4	.0022	153.
500°	932°	Stone 1:2:4	.0023	160.
1,000°	1,832°	Stone 1:2:4	.0027	188.
1,100°	2,012°	Stone 1:2:4	.0029	202.

A brief comparison of these values with those for other materials may be interesting.

The specific heat of concrete is slightly less than that of either red brick or fire brick, hence the same amount of heat needed to raise the temperature of a pound of brick is about 10% more than for a pound of concrete. But the density of concrete is enough greater than that of brick to raise the heat capacity of a cubic foot of concrete above that of brick. The difference is not large, however.

While the expansion data are not complete, it seems clear that for a time after the beginning of exposure to fire the concrete and its reinforcement will expand at much the same rate, but that the further expansion of the surface will not proceed at so rapid a rate. This will tend to reduce the stresses which the expansion of the heated surface would otherwise set up in the cooler interior. It is perhaps because of the failure of the concrete to return to its original dimensions that the small amount of surface cracking found after a fire is due.

The experiments made with coal and cinder mixtures indicate the necessity of added care in the selection of cinders for this purpose.

The tables of thermal conductivities give us data as to the rate at which heat will travel through concrete. It is interesting to note the great difference between the tamped and the untamped concretes made from stone. The one was as porous as possible, and the other as dense. One transmits nearly twice as much heat as the other. The cinder concrete, as is commonly believed, is much better as a heat insulator than the stone concrete, being nearly three times as effective as the denser stone concrete in retarding the flow of heat. It may be interesting to call attention to the heat insulation afforded by other materials. The best of the commercial articles used for this purpose is compressed cork, which is nearly 25 times as effective as stone concrete. Steel, on the other hand, transmits heat from 75 to 100 times as fast as the densest of the stone concrete.

A Large Wire Rope of Unusual Construction for a Cable Incline of the Mayari R. R., Cuba.

By FRANK W. BUNN,* M. Am. Soc. M. E.

A wire rope of exceptional type has been recently made for use upon a double-track cable incline forming a part of the Mayari R. R. This railroad was built by the Spanish-American Iron Co. for transporting iron ore from the top of Mayari Mountain to Felton terminal on the north coast of Cuba, a total distance of some 17 miles. The main haulage rope to be used upon the incline is 3 ins. in diameter, 7,810 ft. long and weighs 123,360 lbs. It is composed of an independent wire rope center 1⅛ in. in diameter, made of six strands of 19 wires each twisted around a hemp core. Six other strands of 19 wires each are twisted around this center.

This construction is without precedent in the manufacture of so thick a rope. The diameters of drums and sheaves over which a rope runs are generally such that, in cases where it is proposed to employ a rope of unusually large diameter, it is necessary for the sake of pliability to materially increase the number of wires in each strand. Where the sizes of drums and sheaves have not been controlling in this respect, the great difficulty of drawing strong thick wires that will readily twist into rope has prevented the use of the standard construction.

The operating machinery of the Mayari R. R. planes consists of a pair of drums, 20 ft. in diameter, between which, and meshing with gears on the drums, is a pinion 58½ ins. in diameter, carried on the crank shaft of a double 30 × 30-in., vertical engine. After three turns on the drums, the cable passes back to a reversing sheave also 20 ft. in diameter and thence forward to the second track. At the top, where the track drops off from a slight approach grade through a rather sharp vertical curve into the maximum grade, there are three vertical guide sheaves, the first 16 ft. in diameter and two others 8 ft. in diameter. With this equipment, it is not necessary to abide by the usual limitation placed by drums and sheaves upon the construction of haulage rope and it was decided to obtain if possible the advantage to be derived from the superior resistance of tough thick wires to abrasion. An order was therefore placed for a rope 3 ins. in diameter of the construction known as standard hoisting rope (six strands of 19 wires each and a hemp center) except that, instead of twisting the six strands about a hemp center, the center

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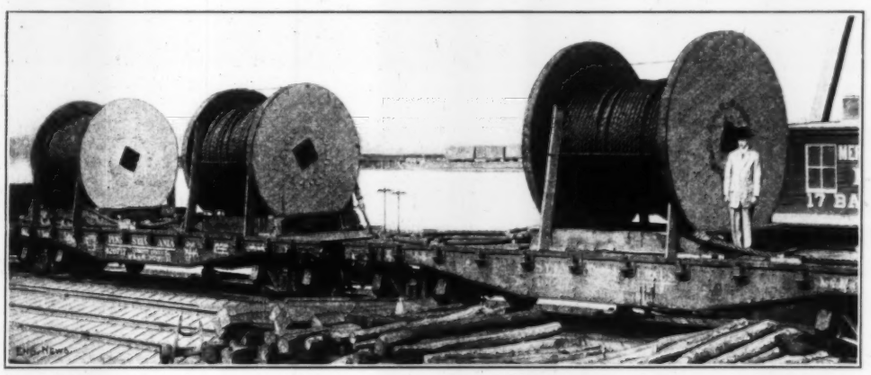
was to be formed of an independent wire rope, as already noted.

The production of the wire for the rope center did not call for any unusual effort, but to make the wires for the outer strands was a task of great difficulty. These wires range from .175 to .225 in. in diameter, and were required to have, in a combination not heretofore attained in such sizes, strengths equal per square inch to those of finer wires used in rope making, and to possess at the same time sufficient pliability to be readily twisted in the stranding machines. Until recently it has been thought impossible to produce wire of these sizes which would possess throughout the uniform quality necessary for rope wire, but improved processes in the heat treatment of steel have made it possible to obtain the desired uniformity. The wires were drawn from a high grade of plow steel and before being placed in the stranding machines were tested by taking sample lengths from each end of each coil. These samples were subjected to tests in bending, torsion and direct tension.

When the rope was completed, the manufacturers were confronted with the problem of loading it for shipment from the factory and re-loading on a vessel in New York. The weight of the rope was much too great to allow the reel on which it was coiled, in making, to be loaded on a single car. It therefore became necessary to load on two cars, and to facilitate reloading on



7810 FT. OF 3-IN. WIRE ROPE WOUND ON THREE REELS FOR LOADING ON TWO FLAT CARS.

(The rope weighs 123,360 lbs., exceeding the capacity of one car.)

the rope's length, had to be distributed on three reels.

This was done by mounting an empty reel about 200 ft. from the main reel, and revolving this reel until it had taken from the main reel one-half the rope's length. The reel was then moved and another empty reel put in its place. The rope was looped around this reel in such a way that when it revolved it took rope in equal lengths from both the main and the secondary reels. This was continued until one-third of the rope was wound on each of the reels. The largest of these reels was 10 ft. high by 9½ ft. wide. The other two were 8½ ft. high, one being 8 ft. 10 ins. and the other 7 ft. 2 ins. wide. The three reels were loaded with the part of the rope between them coiled on the bottom of the cars, as shown in the accompanying illustration. The reels were lifted off the cars at the dock in New York and loaded on a steamer of the Munson Line for shipment to Cuba.

The incline on which the rope is used is of the tail-rope type, in which empty cars going up act as a partial counterbalance for those coming down. The cable is carried throughout the length of the incline on rollers, made of tropical hard wood, the axles for which run in half bearings also made of hard wood. At each end of the haulage cable is placed a "barney" of cast steel with a bumper supported by suitable springs to relieve the cable of shocks. The tail rope connecting the lower ends of the "barneys," through a sheave 14 ft. in diameter mounted on a tension carriage, is a 1¼ in. diameter, hemp-center wire cable. The contour of incline consists of a series of grades varying from 6% to 25.13% connected by easy vertical curves. Starting at the top the contour is about as follows:

583 ft.	25.13% grade.
2,175 ft.	17% grade.
1,917 ft.	6% grade.
1,829 ft.	25% grade.
213 ft.	vertical curve.
6,716 ft.	total length.

The ore is carried in a special type of steel car weighing about 41,600 lbs. with a capacity of 50 gross tons or 112,000 lbs. The incline machinery is designed to carry three loaded cars, whose total maximum weight would be 460,800 lbs. The maximum stress on the cable occurs when the cars are at the bottom of the 25% grade entering the final vertical curve. At this point, there would be 6,503 ft. of cable payed out weighing, at 15.8 lbs. per ft., 102,747 lbs.

The combined weight of cars and cable would be 563,547 lbs., or 282 net tons. The load on the cable per net ton on a 25% grade would be 534 lbs. Assuming then that all the cable payed out in this case is on 25% grade as well as the cars, the total maximum load on the cable is $282 \times 534 = 150{,}588$ lbs.

For the present it is intended to carry only two loaded cars per trip, producing maximum strain on cable of 109,470 lbs. The inclines were designed to operate at a speed of 15 mi. per hr.

All the machinery for this plane was furnished by the Nordberg Manufacturing Co., of Milwaukee, Wisconsin. The wires for making the rope were drawn and stranded into rope at the works of John A. Roebling's Sons Co., at Trenton, N. J. The steel from which the wires were drawn was made at the same company's works at Roebling, N. J.

Needle Jets of Superheated Steam to Prevent Smoke: the Luckenbach Boiler Furnace.

The use of steam jets in connection with steam boiler furnaces is almost as old as steam engineering itself. Such jets have usually been applied to furnish additional draft, the force of the escaping steam being used to blow air into the ash-pit or over the fire. An incidental and very important advantage of the use of steam jets in the ash-pit is the cooling effect on the fire-bed, which hinders the formation of clinker. Some of the best known systems for burning low-grade fuels depend for their success chiefly on the use of the steam jet to keep down the temperature of the fuel-bed, although, of course, the extra draft furnished is of great advantage in forcing the necessary amount of air through the grates and through the interstices between the particles of burning fuel.

A steam jet system known as the Luckenbach system has been introduced recently to a considerable extent in Chicago and vicinity for the purpose of promoting complete combustion (with inferior bituminous coal) and thus preventing smoke, although considerable fuel economy is also claimed for the system. In the Luckenbach system, which is illustrated herewith, the steam is highly superheated and issues as fine needle jets from orifices located in the furnace walls at a little distance above the fire. The effect of these jets, issuing from opposite sides of the furnace at high velocity, is to thoroughly mix the combustible gases rising from the coal with the oxygen of the air. This thorough mixing is well understood to be one of the most important features in securing rapid and complete combustion.

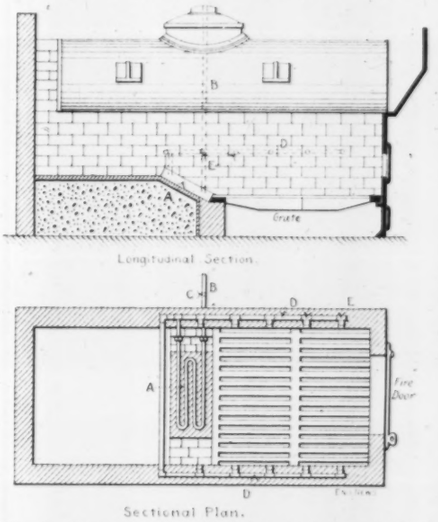


Fig. 1. Plan and Elevation of Horizontal Boiler With Luckenbach Steam Jet Attachments.

The steam is taken from the dome of the boiler and led to a heavy casting built into the bridge wall. In this casting is formed a double pipe coil through which the steam passes on its way to the jets. A valve in the supply pipe is connected to a mechanism operated by the fire door, so that the valve is opened at the same time with the fire door and is automatically closed at a certain interval after the fire door has been closed. Thus the jets are operated during the time when the fresh coal thrown on the fire is giving off a large volume of gases which would appear as smoke if not consumed. After the fire is bright, and there is no further need for the mixing action, the steam valve is closed.

In the accompanying cuts, Fig. 1 shows the apparatus in diagram form as attached to a horizontal boiler, and Fig. 2 shows the details of the blowing nozzle used. It will be seen from the drawing of the nozzle that the steam issues from a flaring opening which tends to spread the jet and cause thorough mixing of the air and combustible gases.

Ordinary running tests and the results in regular service of boilers equipped with this apparatus have shown reduced fuel consumption with greater steaming capacity, together with an almost complete elimination of smoke even when the boilers were being forced. The application of the apparatus also enables an inferior grade of fuel to be used without reducing the boiler capacity and without causing a smoke nuisance. The reduction in smoke also reduces the soot deposit on the heating surfaces of the boiler and the consequent labor of cleaning.

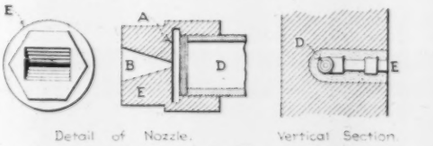


Fig. 2. End View and Section of Luckenbach Steam Nozzles.

At the Medinah Building, in Chicago, the Luckenbach furnace has been in use for 15 months on a 225-HP. water-tube boiler, and has been applied to new boilers which were recently installed. Tests made by Mr. Otto Luhr, mechanical engineer, showed that with this device thrown out of use there was considerable smoke; when it was put into use, the smokestack re-

mained practically clear and at no time emitted smoke which would bring it within the limits of the smoke ordinance. A reduction of the stack temperature indicated that the combustion was completed in the furnace due to the mixing effect of the steam jets.

At the Illinois Athletic Club the apparatus has been applied to the three water-tube boilers of 250 HP. each (the third boiler being kept in reserve). It has not only eliminated the smoke and reduced the fuel consumption, but it gives such efficient combustion that it is now practicable to burn the garbage from the club's restaurant. There are from 10 to 12 large cans of garbage daily, and the charge for removing these was $15 per month, while there was trouble from odors of the stale garbage awaiting removal. Much of this refuse is very wet and sloppy (including waste ice, etc.) It is spread out on the boiler room floor, a small quantity of coal is thrown upon it and it is then fired in the usual way. One of the large dry-goods stores plans to equip its boilers with this device largely for the purpose of being able to dispose in this way of the garbage from its restaurant.

Another example of the use of refuse for fuel is at the plant of the National Box Co., Chicago. There are three 400-HP. boilers, which were formerly fired with shavings, sawdust and wood refuse, making it very difficult to prevent smoke. Since the application to them of this device, the shavings are sold, and the boilers are fired with sawdust, wood refuse and manure from the stables.

The device described above is the invention of Mr. Harry Luckenbach, and is being introduced by the Luckenbach Smokeless Furnace Co., Medinah Building, Chicago. There are reported to be now about a dozen installations in Chicago, and others in New York, Buffalo and Utica, N. Y.

The Relation of the Corps of Engineer Officers, U. S. A., to River and Harbor Improvements.*

By GEN. W. H. BIXBY,† M. Am. Soc. C. E.

Those who have not specially studied the subject may occasionally wonder how and why the river and harbor work ever came to be assigned to the Army Engineers.

During colonial days there was little work anywhere of engineering nature in the United States except what could be done by the ordinary farmer and mechanic. In the days of the American Revolution, the military and topographical engineer came to the front as a military necessity. In 1800, James McHenry, Secretary of War, urging the re-establishment by law of a Military Academy and a Corps of Engineers, said, in his argument, that "fortifications is but a single branch of their profession" and "their utility extends to almost every department of war and every description of general offices, besides embracing whatever respects public buildings, roads, bridges, canals, and all such work of civil nature." In 1802, the Military Academy was established at West Point for the sole purpose of educating engineers for such service.

However, at present, only from 5 to 10% of the West Point graduates, those who appear best fitted for such special work, join the Engineer Corps, the others going to the other branches of the military service.

The U. S. Coast Survey was organized in 1816 by F. R. Hassler, a former Military Academy professor, being later extensively developed by A. D. Bache, a Military Academy engineer officer graduate of 1825. Many of the great topographical, geodetical and astronomical surveys of the United States were originally organized by Army Engineers, or at least by West Point graduates.

Up to 1824, West Point was the only school which taught civil engineering, and all engineering work was necessarily started under the guidance of West Point graduates. In 1824 a specific Act of Congress gave to the Army Engineers the definite charge of all government roads and canals.

The Rensselaer Polytechnic School did not start until about 1824, and the Sheffield Scientific School not till about 1847. When, after the civil war, civil engineering and other technological schools began to develop all over the United States, the Military Academy graduates still held their own good standing in the Civil Engineering profession because of their added knowledge of governmental methods, and their special military training as to careful observation, obedience, and rigid responsibility in all matters of engineering work, property, and funds.

The road and canal work of this country started officially under the charge of the Army Engineers in 1834, was soon extended to embrace occasional rivers and harbors, and so continued until naturally stopped by the civil war. About 1867, such work came to the front again, mainly in the matter of river and harbor improvements, and was naturally reassigned to the Army Engineers, and there it has remained ever since.

So you can easily see that the river and harbor work of this country has come to the Army Engineer Corps by original endowment, and by natural processes of national development, and remains with it as a natural inheritance and duty in which its service has special value to the country at large by reason of its century of special training and of careful, efficient, honest stewardship.

In this connection it may be mentioned that a large proportion of the older Army Engineers are to be found in the lists of active members of the prominent civil engineering societies of the United States, join in their conferences and discussions, and have their confidence and respect.

The Education of Engineer Officers.

Under existing conditions of the Engineer Service, an officer is trained for local charge of a river and harbor district by four years of mathematical, mechanical and civil engineering study at West Point, a year of inspection of the best types of river and harbor constructions and of field practice, another year or two of special study of explosives, electricity, and civil engineering specialties at Washington Barracks, and two or more years of engineering duty with troops. When the district work is reached, it is performed for years under supervision of an older officer.

All specifications and contracts are examined and checked up by the Division Engineer and the Chief of Engineers, and all projects by a special Board of Review and by the Chief of Engineers. No new work is appropriated for by Congress until examination and report by the district officer, division officer, Board of Review, and the Chief of Engineers. With such a system of engineering training and of reports and supervision, all under special direction or approval of Congress, it is almost impossible for undesirable work to be commenced.

The proper progress of work is at present somewhat hampered, it is true, by a shortage of officers; but this difficulty will disappear whenever Congress authorizes the increase of the Engineer Corps as hoped for this year.

Such a system places the river and harbor work of the country to-day in the hands of a body of men free from local interests and local bias, liberalized by constant contact with other parts of the country and other business interests although independent thereof, concerned only with securing good engineering work and the public benefit, and thereby specially fitted for the duties assigned them by existing law.

I think it is due to the Corps which I represent that I put these matters thus simply and plainly before you so that you may know just why the Army Engineers already have the support of the Federal Congress, and why they expect to have that of your Congress, as regards not only our past river and harbor work, but also that of the future.

The system of training and executive organization just described to you is very similar to that of France, where every officer in charge of river and harbor work (with but few special exceptions), must pass through three years of mathematical and civil engineering study in their War Department Polytechnic School, and then three more years of special engineering study in the Government school of Bridges and Highways; after which their district officers are directed and supervised in much the same way as in the United States. And France is noted throughout the entire world, as well as in Europe, for the extent, thoroughness, and perfection of its river and harbor improvements.

How Recommendations for River and Harbor Improvements Are Made.

Whatever may have been the condition in former years, the day has now passed for the appearance in coming river and harbor bills of any new projects where the worthiness of the improvement is subject to any reasonable doubt. The special provisions of Congress with respect to the investigation of any new river and harbor projects have raised so many safeguards that it will be practically impossible for any unworthy project to get into coming river and harbor bills unless Congress changes its present rules.

As an illustration, with one or two minor exceptions, the river and harbor bill of the last year introduced no new projects that had not already received the sanction of the Engineer Department and of Congress, excepting a few cases where the actual appropriations or actual expenditures were made dependent upon future favorable recommendations from the Engineer Department as regards worthiness. For the present year the estimates of the Engineer Department contain no provisions for any work adopted in recent years, except where the project has been recommended by existing law, not only by the district officer, but by the Board of Engineers and the Chief of Engineers, after careful consideration by all three offices.

In fact, all the money which the country could spare for several years to come might be easily expended on projects that have already passed such examinations and received such recommendations; Congress having already received from the Engineer Department favorably-recommended projects to an extent of cost of about two hundred million dollars in excess of the amounts already appropriated.

All of these projects are expected to give to the country final results worthy of such cost, and the question is no longer whether any of them are worth executing, but simply which ones should be undertaken first, and how fast they can be pushed forward to completion. All we have to do from now on is to select those most urgent, and those most beneficial to the public at large, giving preference at times to those where the local public are willing to cooperate by substantial contributions.

This is all the more easy to-day because this country has already reached the stage where the people are on the one hand becoming daily more and more reluctant to approve any stagnation or false economy by which great public interests are sacrificed, and more willing to make large expenditures where great public benefits are probable, and yet, on the other hand, are daily adding to their growing contempt for all parties, whether individual or corporative, who regard the general public and the public purse as something to be squeezed and exploited for private gain.

In past years we have given the largest appropriations to seaboard ports, which you must admit was right and proper when you remember that these ports are the main outlets of the country, receiving raw materials and manufactured products from all interior states and sending them abroad to the rest of the world. From now on, however, we might well afford to give greater prominence to the interior waterways.

The Importance of a Definite Policy and Continuous Work.

More than twenty years ago when the American Society of Civil Engineers was discussing certain features of public engineering work, there was a decided unanimity of opinion that the best engineering work was that which gave the best results per dollar of expenditure, and that such results could not be secured to the public except by the aid of liberal annual appropriations allowing consecutive systematic work by permanently organized working forces and working plants.

The greatest obstacle in the way of effective work of river and harbor improvement has been the intermittent character of its work, causing constant doubt as to the amount and date of forthcoming funds; but the *now proposed annual bills* are expected to remedy this trouble. When new appropriations are made, the public expects active field work to be started immediately, apparently forgetting that it takes much time to build or collect plant and to collect and organize working forces. Then when work is nearing completion, the public expects the last cent to be put into it, apparently forgetting that funds must be reserved to collect, store, and preserve its working plant and to hold together the most important portions of the working organization until work can again be started.

Every year, at the request of Congress, the Engineer Corps submits estimates of the amounts which can be advantageously and economically expended upon river and harbor work; and yet every second or third year for many recent years, Congress, in accordance with its understanding of the desires of the public, has felt obliged to reduce these estimates very greatly or perhaps to omit them entirely on the ground that the expenditure is not sufficiently necessary or that the funds are more needed by other Bureaus of the Government.

I believe you are justified in continuing your active forceful campaign for educating and enlightening the general public on such matters until a positively certain annual appropriation bill for river and harbor improvement shall become as much a necessity and reality as that of the postal service.

Another obstacle to efficient river and harbor work has been the quite common lack of sufficient appropriations to provide for the prompt completion of such projects as have been pronounced worthy by the Engineers and by Congress. It seems to me far better from a business point of view to promptly complete such projects as cover important terminals, extended through lines of busy water transportation, and routes of moderate cost and moderate depth through existing streams from promising but undeveloped areas to the seaboard, than to start new work over a large number of local harbors or to attempt the deepening of water routes already adequate to the business in sight.

It appears to me that it is perfectly proper and exceedingly desirable for your association, convinced as it is of the economy, advantage, and need of expenditures for river and harbor improvements, to extend your investigations also into the question of why you prefer to have your money spent upon river and harbor work in

*From an address delivered before the National Rivers and Harbors Congress, held at Washington, D. C., Dec. 8, 1910.

†Chief of Engineers, U. S. Army, Washington, D. C.

preference to other public works, how extensively you really wish it so spent, and how arrangements can be made for greater regularity of such appropriations without serious injury to other public interests. It seems to me especially desirable that as your investigations proceed, you should make the results known, not only to the public of your neighborhood, and to the local engineer officer in charge of examinations and surveys, but also to your local Congressman, who can press the matter to further conclusions in Congress.

In other words, you have before you, as a natural duty, the development of a strong public opinion in favor of waterway improvement up to its economical limits, and the transmission of such opinion to your Congressman in such tangible form that he can use it efficiently on the floor of Congress.

The Army Engineer Corps is already guaranteeing an economical and advantageous expenditure of the amounts appropriated, and recommending projects of undisputed worthiness; and Congress will assign the appropriations you desire just as soon as you convince Congress as a whole that such appropriations are not only desired, but are urgently needed in the public interest.

There are some special points regarding navigation problems which have been considerably cleared up by recent investigations in Europe and which it may be well for me to allude to in order to assist you in clearing up your own ideas on such subjects.

Depth of Channel of Secondary Importance in Inland Navigation.

The question of deep draft is one of them. Large, single, deep-draft boats are a necessity on the ocean, and even on large bodies of inland water, such as our Great Lakes; but this is more to gain strength against the effects of high winds and heavy waves than to secure an economic propulsion of the vessel. Recent experiments in France, England, and Germany, have shown that on canals, on ordinary rivers, and on all waters where the winds are small, where waves are of little height, and where the currents are moderate, the resistance to towage or propulsion is approximately doubled by doubling the draft of the vessel, but is only increased 5 or 10% by doubling its length. Consequently, on interior rivers and canals where the water area is not fully occupied all the time by the passage of existing boats, it is far cheaper, so far as towage or propulsion is concerned, to use a large number of individual light-draft boats combined in large trains one behind the other, or sometimes in separate boats with small power to each boat than to attempt to carry the same load in a single boat of great draft. This is also the European practice.

This is clearly proven by the case of transportation of coal tows on the Ohio and Mississippi rivers and also by the fact that on the Mississippi River itself between New Orleans and Baton Rouge, a distance of about 140 miles, with a depth of nowhere less than 25 to 30 ft., on the shallowest bars, and with a wide channel, navigable at all hours of the day, night, and year, the goods to be transported are carried to-day by comparatively shallow draft steamers rather than by the deep draft ocean boats which have brought them to New Orleans.

What we need in the United States in the way of river improvement is not so much increased width or depth of existing rivers, as to have those rivers thoroughly clear from their own natural obstructions, such as rocks, snags, fallen timber, and river bars, so that their existing depth can be fully utilized by any boats able to reach them.

With the recent increased use of gasoline as a means of propulsion, the character of navigation on our interior streams is already beginning to change. A gasoline barge drawing only 2 ft. can in quiet water carry loads heavy in proportion to each dollar of expenditure for propulsion. Such a boat might easily have gone at any time on any day during the navigation season of the last hundred years from the mouth of the Mississippi River up to Fort Benton on the Upper Missouri, a distance of over 2,200 miles. In fact, a good deal of the most profitable business of the Upper Missouri River to-day is being done in just such a manner by small gasoline boats, which are used as feeders to the railroads in the neighborhood of their river stations.

Municipal Control of Waterway Terminals.

Another important point developed in Europe in the past year is the fact that no waterway can be used to its full capacity until it is provided with improved terminals, having all modern facilities for unloading and reloading and for transfer of cargo between railroads and steamboats in such ways as has been done for years on the Great Lakes at the ore docks of Lake Superior and at the coal docks of Lake Erie.

Another point of great importance is the necessity of all proper control of these terminals by the municipalities of commercial ports, and the establishment of arrangements by which railroad lines will give through bills of lading and all loading and other transfer facilities to any freights, as may be desired by shippers along and over lines of mixed railroad and water routes.

One of the first steps to be taken toward the utilization of existing and future improved waterways should be a general preparation by all large river and harbor towns and commercial ports for municipal control of wharves and docks, and for the construction of terminals and transfer facilities. This does not mean that wharves, docks, and transfer facilities must be actually built prior to any large demand for the same; but it does mean that each municipality should obtain prior control of the wharfage front and its surroundings to such extent that when the time arrives for a needed increase, and when people are found who are willing to put up the money for their construction, there shall be plenty of room for carrying such projects to completion, that all facilities for such work shall be ready, that all obstacles in the way of such work shall be removed, and that when such constructions are actually built, they shall be available to the general public at moderate rates and free of all monopoly.

Volume of Traffic Necessary to Make Waterways Profitable.

Another point is the fact that not in any part of the United States, nor in any part of the world, can water transportation be made profitable unless it is possible to have at one end of the route natural products which can be bought cheaply, and at the other end of the route markets for their consumption where goods can be sold at a high enough rate to pay for the cost of transportation between the two terminals.

It is mainly due to this latter condition, rather than to the depth of the waterway, that we have seen such an enormous development of commerce on the Great Lakes. On the borders of Lake Superior are enormous volumes of iron ore which are needed in the East; and around Ohio, and Pennsylvania are enormous beds of coal which are needed in the West, so that boats plying between these two places can carry full loads each way during the entire length of the navigation season.

The reason why more depth is needed along this route at the present day is because the existing travel is so great that even during the daylight hours the connecting waterways of the St. Clair, St. Mary's rivers, and the Sault canal, are filled to their utmost capacity, and increase in depth is the only method left for expansion of the waterway.

The Effect of Waterways in Reducing Railway Rates.

Another point in general waterway improvement is the fact that it is not always necessary that every waterway should be utilized to its full capacity, or even to any appreciable capacity, in order to justify its existence, or its construction, and its maintenance. For example, the Illinois State canal which has existed for many years between Lake Michigan and the Illinois River, with an original 6-ft. depth, allowed to deteriorate to 4½ ft. depth because of lack of toll receipts, must not be considered as an idle canal or as one not worthy of maintaining.

So long as a waterway is kept open, even with no boats moving on its surface, it is at work day and night in maintaining for the benefit of the people along its banks and connecting water routes a transportation rate sometimes as low as could be secured from the waterway itself if covered with laden boats. One of the recent reports of the Illinois State Canal Commissioners contains a contoured map of freight rates along the banks of its canal, and for several miles on either side, which proves my statement to be beyond question of doubt. The same condition exists on the Missouri and the upper Mississippi. Under such circumstances the important thing is an open route of moderate depth rather than an increase in depth. In such a case what the general public sees is not half as important as some of the things it does not see nor think of.

American Waterways Far Superior to European Waterways.

Several years ago there was a considerable cry throughout the country that the United States was away behind the rest of the world in matters of waterway improvement and waterway utilization, and statements were made broadcast that if the United States could only be given a system of waterways equal to those in Europe in length, breadth and depth, there would be an immediate enormous development of water-borne commerce. The fact is, however, that the most of our water-borne commerce difficulty is due to other things than merely the depth, width and length of our waterways.

Last year, after careful investigations extended over several years, the British Royal Commission on Canals and Waterways finished and submitted a report upon the advisability of doubling the depth and capacity of British Canals. In its report and as an appendix thereto, this Royal Commission gave careful statements as to all the waterways of France, Belgium and Germany, including extensive and valuable tables of details as to the cross-section, capacity and tonnage of these waterways.

The results show that no matter whether you consider merely navigation of 2 ft. depth, or of 6 ft. depth, or 10 ft. depth, or 20 ft. depth, the United States has in existence more miles of good navigation than France, Belgium and Germany all put together; and that if it were possible to trade off the waterways of the United States for the waterways of Europe, it would be Europe and not the United States that would be the beneficiary by the transaction.

It is difficult for the general public to make proper comparisons between the waterways of this country and Europe, and to draw therefrom correct deductions. The differences between the two parts of the world are too great. In comparison with the United States, Europe has an enormous and densely settled population, and consequently it has more mouths to feed, more bodies to clothe, more people to house and more natural and manufactured products to transport per square mile of country or per linear mile of river.

For example, entire Europe averages 107 inhabitants per square mile against 46 for the entire United States. In Germany the density of population is 290 per square mile, and in Belgium 620, while in many parts of the United States in the neighborhood of our improved rivers the population is scarcely more than 40 per square mile.

Moreover, as a general rule, throughout Europe the use of waterways and of railways is controlled by the General Government in such a way that there is always maintained a difference between freight rates by water and those by rail sufficient to encourage the use of these waterways to a much greater extent than is possible in the United States under our habits and customs. When the United States becomes as densely populated as Belgium, it will be difficult to find enough railroads and waterways to supply even the emergent needs of our population.

River Improvement for Flood Protection and Water Power.

I occasionally see in the newspapers and in reports of meetings of commercial or professional organizations, queries raised as to why the Engineer Department has so far done so little in the direction of bank protection, reclamation of overflowed lands along the lines of rivers, and the development of water powers.

The Engineer Department has always been liberal in its recommendations for bank protection wherever it directly concerned the navigation of the stream; and liberal in recommending methods for keeping water within the river banks and away from land subject to overflow; and it has always been in favor of the development of water power wherever lock and dam or slack-water navigation is advantageous; but it has always been prevented in the past from going any further because not so authorized by Congress.

While the Engineer Department has always recognized the advantages of liberal bank protection to save and protect property, and of levee construction and drainage to reclaim overflowed lands, and of water power development to secure power to operate factories, it has been obliged to consider that its work was restricted to navigation interests until expressly otherwise authorized by law.

At the last session of Congress, the Engineer Department was requested in future river and harbor projects to take into consideration the development of water power and to submit recommendations wherever the cost of navigation improvement might be lessened thereby; and all new river and harbor improvements are being considered accordingly. This does not mean, however, that the Department is to investigate water power development for power purposes alone, but only when the river improvement work itself shall receive a direct and appreciable benefit, and the development of water power forms a logical part of the navigation improvement. Anything in excess of this must still await the further orders of Congress.

Pending River and Harbor Appropriations.

It seems proper that I should explain briefly the manner in which the recommendations of the Engineer Department for this year have been drawn up.

The printed Annual Report of the Chief of Engineers, for 1910, just distributed to Congress, contain the following:

ESTIMATES.—The following estimates are submitted by the Chief of Engineers for the fiscal year ending June 30, 1912:

Under continuing contracts	$7,368,077
Rivers and harbors (general, including Mississippi River Commission, and examinations, surveys and contingencies)	22,627,361
Under California Debris Commission (expenses)	15,000
Prevention of deposits in New York Harbor	85,260

These estimates are intended to cover only the minimum requirements for the prosecution and maintenance of the various improvements, such estimates having been made up from other estimates prepared on the same basis by the various district officers and carefully revised by the division engineers; this being done in order to keep within the limited total estimate deemed advisable for the next fiscal year and on the supposition that river and harbor work will be provided for hereafter by annual appropriations.

The total amount recommended for appropriation in the next river and harbor bill (excluding examinations, sur-

veys, and contingencies) is $22,227,361, to be applied to 211 works. Of this amount about 10% is to be applied to the restoration and maintenance of completed work at 136 localities so as to secure the continuance of benefits resulting from past expenditures; practically 70% to prosecuting work on the Ohio, Mississippi, Detroit, Hudson, Delaware, and Columbia rivers and at 11 important harbors; and the remaining 20% to the prosecution and completion of 32 other works.

Of these 82 works, 22 are recommended for completion by immediate cash appropriations, and 11 for completion by partial cash appropriations, supplemented by continuing contract authorizations; 31 of the remaining 49 works are being prosecuted in whole or in part with government plant by hired labor under conditions where, with regular appropriations assured by annual river and harbor bills, provision in excess of the year's needs is not regarded as essential at present.

The remaining 18 works for which provision for completion is not recommended are those at localities where, due to the character of the improvement, conditions to be fulfilled by local interests, or other special reasons, provision for completion is not regarded as essential at this time. In some cases where provision for completion is not recommended changed conditions, since the improvement was undertaken, may render entire completion of the project unnecessary, although a partial completion is nevertheless required.

Liberal appropriations are considered proper and desirable for snagging and other work necessary to make natural channels available wherever water-borne commerce exists or is reasonably prospective. It is believed that expenditures for such improvements are almost always useful and advantageous to the general public, especially since the introduction and rapid development of small gasoline motor boats for combined freight and passenger transportation. In many cases it is apparent that the failure to use a waterway is due not so much to lack of channel depth as to the presence of snags and other obstructions which can be removed, at comparatively small cost, thus making the natural channel depths fully available throughout the year. When the boat commerce develops or its requirements become greater the existing clear channel will be in its best condition for further and more expansive improvements.

If desired by Congress for its consideration in providing for new works, reports could be submitted by the Board of Engineers for Rivers and Harbors and the Chief of Engineers upon the relative importance of the various improvements recommended as worthy of being undertaken by the United States, the order in which the works should be taken up, and the rapidity with which they should be completed, upon methods of standardization by which the waterways of the country could be improved uniformly in proportion to their capacities and to the existing or probable demands of general commerce, or even report upon a systematic scheme of such improvement embracing all waterways, whether heretofore examined and reported upon or not.

The first step toward the preparation of the estimates to be given to Congress, was taken last June when letters of instruction were sent out to all the district engineer officers asking them to submit as usual estimates for their districts and show how much money they could advantageously spend on each river and harbor work in their charge during the fiscal year commencing July 1, 1911. When these were received it was found that the cash amounts totaled about $43,000,000.

The estimates as to the Government revenue for the coming year and as to the amounts needed by other Departments for the same period, led the President to believe that only about $30,000,000 could be spared this year for river and harbor work under both the river and harbor bill proper which provides for general work, and the sundry civil bill which provides funds for contracts already authorized; and he issued instructions accordingly, stating, however, that a carefully prepared bill of this amount would receive his approval.

This made it necessary for the Engineer Department to reduce the cash estimates for the river and harbor bill proper to about $23,000,000. Under such circumstances, the only method which could be consistently adopted was to treat the work in the same manner as such work would be treated by a commercial organization with limited income, and the only way to do this with justice to all parties and with the best results to the country at large was to find out how much money out of past appropriations would probably be left unspent on June 30, 1911, and then to add to such balance for each district enough money to carry work successfully through another year on the assumption that the next session of Congress would enact another river and harbor bill.

In other words, we have proceeded on the assumption that from now on we can count upon regular annual appropriations as desired by the general public, as practically promised by the present Congress, and as approved by the President, all with an eye to judicious, economical advantageous work.

Such reduction required in some cases the omission of all the estimates for some existing works and the reduction of other estimates to amounts which are liable to be quite disappointing to localities concerned. But in order to facilitate the resumption by Congress of annual river and harbor appropriations, it seemed necessary this year to make the bill a small one, so small as to insure no doubt as to its passage; and it was thought that when such condition became generally known, the country at large and each locality in particular would be willing this year to assent to such sacrifices for the general public good.

It seems already probable that if the general public will this year trust to Congress and to the President and assent without opposition to such a bill as already started, such bill will be passed early in the session, the annual passage of future bills will be assured, and one of the most important objects of your association will have been accomplished.

A Discussion of the Basis of Design for Reinforced-Concrete Flat Slabs.*

By ARTHUR R. LORD.†

In this paper the writer desires to state briefly, without attempting to make connections or applications, the evidence presented by the test on the floor of the Webber and Deere Bldg., in Minneapolis, described in a previous paper,‡ and also such confirming evidence from other tests made recently at the University of Illinois, as is applicable to a consideration of the basis of design for reinforced-concrete floor slabs.

The division of the slab into beams or beam strips gives a method of analysis which appeals to many as the logical manner of approach in undertaking the analysis of the reinforced-concrete floor slab. It does not seem, however, that the *true* stresses may be so arrived at, but we may safely conclude that the stresses so found will represent the *maximum* value.

It must be recognized that the stresses indicated by the beam method of analysis are reduced by slab action and by arch action to a very considerable degree, but it is not possible to state coefficients for this reduction or to give it quantitative expression at present. The amount of this reduction probably depends on the depth of the slab and on the details of the head and slab reinforcement, and may be expected to vary considerably under different conditions.

Certain lines of approach do not seem to be tenable as a basis of analysis. Whatever the value of Grashof's analysis of homogeneous plates fixed on a system of equidistant points may be (and this value is not clearly established), the use of the ratios from Grashof does not seem to be warranted without advancing weighty supplementary evidence. Other writers have pointed out the important bearing which Poisson's ratio has on the value of the stress found by Grashof's equations. The writer would mention also that the expression found by Grashof is indeterminate for other than square panels, and that the maximum stress is located at the center of the cross band (as applied to the floor slab) and not at the support as Mr. A. B. MacMillan§ evidently supposes. This can hardly be said to represent the conditions in the reinforced concrete floor slab.

Treatments based on Dr. Eddy's analysis of the circular flat plate do not seem to apply for the same reasons. Dr. Eddy's analysis assumes certain relations in both shear and moment curves which, while tenable for the cases that he treats, do not seem to be applicable to a plate supported over a considerable area at its center. Dr. Eddy does not attempt to apply his analysis to any similar cases.

A study of stress conditions would indicate that certain limitations should be recognized in designing the flat slab. Beam analysis applied to the slab and the results of tests both indicate that the moment is greater over the support than at the center, and that the critical section is at or near the edge of the capital. If this be true, and we wish to adhere to the established practice of maintaining the same slab design for all floors, it is essential that the capital be also maintained at or above some minimum size, for which minimum size the moments have been figured. Common practice makes the capital size depend on the column size, when it should depend on the dimensions of the panel. The stresses in the steel and concrete due to moment and the shearing and diagonal-tension stresses are all increased rapidly by a decrease in the size of the capital. Over the small capitals in the upper floors of buildings of this type the stresses must be much higher than they are for the lower floors with their large capitals. From a study of shear and moment stresses in several buildings it is recommended that the capital be maintained at a diameter of at least two-tenths the dimension of the side of the panel, if the capital is square, or at an equivalent area if the capital be of different shape. Shearing and diagonal-tension stresses will be safe for this size of capital provided a proper percentage of steel is used in the slab design proper.

It is quite commonly held that only the rods which pass over the capital may be taken into account in figuring the resistance to negative moments. Under this conception the strips containing the outer rods of a band serve only to carry load to other strips which they intersect and which do pass over the capital. In this conception it would seem that there is a confusion between transfer of weight and of stress. The weight or load follows the most direct path to the column, being transmitted in the form of shear in the concrete itself, and does not need to be transferred from strip to strip at their intersection. The wide beam while stressed very high at the support locally in shear, may be stressed over its entire width in moment. A series of tests made during the past year at the University of Illinois illustrates this lateral distribution of *stress* in wide beams. These beams were of various dimensions and proportions, and we may be permitted in advance of the full publication to present one particular set in which the proportions were very near to the conditions found in ordinary building design. The beams were 36 ins. wide, 4 ft. 10 ins. long, and 3 ins. deep to the steel. Thus the ratio of depth to width is 1/12 or somewhat in excess of the usual ratio of depth to steel to width of band in the flat slab. The beams were loaded across their full width at the ends, and were supported at the third points, in some cases for their full width, in others for one-half their width, and in still others for one-fifth of their width. The beams were made and tested in duplicate at approximately 60 days. The table gives the loads carried.

		Total Load Carried		
Beam No.	Supported.	Beam No. 1.	Beam No. 2.	Average.
711.1 — 2	Full width	15,550	15,800	15,770
713.1 — 2	Half width	15,000	17,000	16,000
715.1 — 2	Fifth width	14,900	12,250	13,500
717.1 — 2	Fifth width	14,550	16,000	15,300

The 717 beams were provided with 0.4% cross reinforcement. All the beams had ten ⅜-in. round rods 3 ins. from the face, and beams 717.1 — 2 had ¼-in. round rods 4 ins. on centers crosswise of the beam.

We may note that for one-half support there was no appreciable falling off in the load carried. The deflection curves showed also that the steel at the edges took the same stress as did the rods in the beam supported for its full width. The yield point of the steel used was 37,000 — 38,000 lbs. per sq. in., and computations show that all the steel present in both cases was stressed about 10% beyond the yield point when the yielding of the steel caused the concrete to fail in compression. This is exactly the phenomena of the ordinary beam test where there is no question of lateral distribution involved. When the beam was supported for only one-fifth its width there was but a small falling off in the load carried. For all cases where the recommendation if this paper with regard to column size is followed the beams or bands will be supported for one-half of their widths, in which case the entire steel would seem to be effective.

The evidence of the wide beam tests is further confirmed by tests of footings. It may be pointed out that the portion of the slab inside the line of inflection is in effect an inverted footing loaded with a peripheral load at the line of inflection (reactions of the supported beams between the lines of inflection) and a uniform load over the base. The footings tested were of uniform depth throughout, being somewhat thicker in proportion than the cantilever slab about the column. From a consideration of all the results Prof. Talbot has arrived at the conclusion that the width of the resisting section, as governing the stress in the steel, was composed of the width of the pier, plus the depth to the steel on each side of this, plus one-half of the remaining width of the footing.

Applying this to several designs revealed the fact that this width includes all the steel in both the cross and diagonal bands in all ordinary designs. In other words, not the steel passing over the capital only, but the entire steel in both bands may be counted on to take its full resisting moment. Actually observed stresses found in the building test, bear out this statement. The stress was found to be nearly constant across the entire band, the slight falling off in the case of the outer diagonal rod being accounted for in part at least by its lower position in the slab. To offset this the outer rods of the cross bands were observed to be taking a slightly higher stress than those in the center of the bands.

The footing tests previously mentioned afford evidence also as to the position of the section at which negative moments should be figured for any band. The reinforcement in the footings was laid sometimes in two bands and some times in four bands without any noticeable effect on the strength or the stresses found in the specimen. The tests have been interpreted for a bulletin on footings now in manuscript form and the conclusion was reached that stresses figured for a section at the face of the pier would represent fairly the structural action involved. Additional evidence was afforded from the observation of cracks about the columns in the building tested. These cracks formed at a distance of about 2 ins. on the average outside of the edge of the capital below, and would seem to indicate that moments may safely be figured about a section at the edge of the capital as giving a maximum condition.

If we consider the bands as continuous wide beams we should expect to find that the moment at the support was twice that at the center of the span for uniform loading. The test indicated that this center moment was somewhat less in proportion, but it is possible under a single panel loaded that the stress at the center may reach as high a value as one-half that at the support under full load, and this fraction may be considered a maximum for design purposes. Much current practice is in direct contradiction to this conclusion. This objection to any adaptation of Grashof's analysis has been noted in a previous paragraph. Mr. C. A. P. Turner's formula, based as it apparently is on tests of single panels and without the determination of actual stresses must be applied with caution. When a formula is to be derived from tests it is essential that the tests be so planned as to give as high stresses as may reasonably

*A discussion presented before the Seventh Annual Convention of the National Association of Cement Users, New York, Dec. 12-17, 1910.

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‡Engineering News, Dec. 22, 1910, p. 695.

§Engineering News, March 31, 1910, p. 364.

be expected under full load conditions. Certainly tests which from their nature predetermine low stresses at the critical section at the support do not constitute an acceptable basis for a design formula. Mr. Turner's contention that by the use of a uniform grade of open-hearth steel it is possible to tell when the stress in the steel reaches the yield point and that in this manner a basis of design may be arrived at, does not inspire one familiar with test phenomena with much confidence. It does not answer the objection to single panel loads at all.

Again it is not clear that any noticeable change will occur in the slab when the steel at the support reaches the yield point. At this time the steel over the support starts to yield; simultaneously the deflection and hence stress at the center increased, and thus relief is afforded the steel at the support. The final failure may even occur at the center, and yet it is evident that this readjustment should not be necessary in good design, even if there is sufficient over-reinforcement at the center to carry safely the added stress (which is not always the case). After the readjustment has taken place there are present in the steel and concrete large permanent stresses and marked set, and against a repetition of the load the structure is even less secure than at first.

The test of the loaded building at Minneapolis indicated that the line of inflection lay between a square having the column at its center and its inscribed circle. If the slab be considered as simply supported the least dimension of the line of inflection (in the cross band direction) would be approximately 0.44 L where L is the dimension of the panel. Owing to the fact that the slab is fixed for a considerable area at the column capital, the effective clear span is much reduced, and the least dimension of the line of inflection correspondingly increased. If we take the effective clear span as the distance between the critical sections already determined for negative moment, which seems a reasonable basis, and if we follow the recommendation as to size of capital stated previously in this paper, the least dimension of the line of inflection becomes $0.2\ L + 2\ (0.22 \times 0.8\ L) = 0.55\ L$ (the $0.8\ L$ being the effective clear span.) In the building tested at Minneapolis the capital size was $0.24\ L$ and the observed least dimension of the line of inflection (in other words the dimension along the cross band) was about $0.56\ L$. On the basis given above it would figure at $0.24\ L + 2\ (0.22 \times .76\ L) = 0.57\ L$, which checks closely with the observed fact. It would seem that for the conditions found in practice, and if columns are not permitted to have unduly small capitals, the variation in this dimension of the line of inflection would be small, and the value of $0.55\ L$ here given may be quite generally applicable. The dimension of the line of inflection along the diagonal band was observed in the test to be about $0.64\ L$.

A question exists as to the values of the compressive stress in the concrete at the edge of the capital, and as to whether or not compressive reinforcement is needed. It is difficult to compute the stress at this point owing to the fact that the concrete is stressed not in one, but in several directions. In the test, however, the resultant stress was measured directly, ranging from 650 to 750 lbs. per sq. in., which is undoubtedly safe for concrete stressed in several directions and over a very short distance. In the design of this building a very low percentage of reinforcement was used at the center of the span, and it would seem as though the use of this low percentage were imperative to proper design unless compressive reinforcement is to be used. We may well ask what the stress in the concrete would have been had ½% or 0.6% reinforcement been used at the center as is frequently done. For such practice compressive reinforcement seems to be required.

The writer would like to add a word on the question of shearing stresses in flat slabs. To the designer of beam constructions these stresses have seemed high, and a proper consideration of shear, as well as of moment, makes it advisable to provide a larger capital than is ordinarily used on the upper floors of our present buildings. The recommended minimum size of capital of $0.2\ L$ was selected with the shear computations of several buildings directly in mind. We should remember, however, that a sharp distinction should be made between so-called "punching" shear and shear which indicates the tendency to diagonal tension. Punching shear may properly be figured along the periphery of the capital giving a punching shear unit stress of

$$v = \frac{W\ (L^2 - c^2)}{12 \times 4\ cd} = 0.1\ \frac{wL}{d}$$

the last simple equation applying only when the capital is $0.2\ L$ on a side as recommended (or a circle of equivalent area.) In this formula

L = side of square panel in feet.

c = side of equivalent square capital in feet = $0.2\ L$.

d = depth of slab in inches.

For such shearing stress the value recommended by the Joint Committee of 120 lbs. per sq. in. is certainly permissible.

In computing shear as indicating the tendency to diagonal tension, we should give to the flat slab the same treatment which we accord to beam design. In a restrained beam we find that the failure in diagonal tension does not occur at the support, but at some distance out from it. In like manner Prof. Talbot has found in the test of footings that the failure in diagonal tension took place some distance out from the pier, and he concludes that as an indication of the tendency to diagonal tension the *intensity* of shearing stress should be computed on a section at a distance out from the pier (or edge of capital) equal to the depth of the slab to the steel. Using the same notation as mefore

$$v' \text{ (diagonal tension tendency)} = \frac{w\ [L^2 + (c + .167d)^2]}{12 \times 4\ (c + .167d)\ jd}$$

In any particular case it is simpler to figure this stress directly than to use the formula. For this value the various limits specified by the Joint Committee should govern.

It is a simple matter to state the above conclusions and recommendations in the form of an analysis, but it is not believed that analysis are profitable until some means is found for expressing quantitatively the amount of the reduction in stresses due to arch action and slab action. The amount of this reduction was observed in the test to be large.

Sound Copper Castings of High Electrical Conductivity.*

By E. WEINTRAUB.†

The production in the foundry of pure-copper castings, mechanically sound and possessing an electrical conductivity comparable to that of pure forged copper, has been an important problem ever since the development of electrical machinery and apparatus. Obstinately, however, the casting of high-conductivity copper refused to make its entrance in the foundries and it may be assumed that there were good reasons for it.

The cause of the difficulty has been sufficiently well understood for a long time. Molten copper has the property of dissolving gases such as oxygen and of setting a part of these gases free on cooling. This produces pin holes and even big cavities. The casting obtained is, therefore, mechanically unsound and has a low electrical conductivity.

The elimination of these dissolved gases presents but little difficulty. It is sufficient to add one of the well-known deoxidizers such as zinc, magnesium, phosphorus, etc., in small quantities to bind the oxygen chemically. Copper castings free from blow holes are thus easily produced. The electrical conductivity of the copper thus produced is, however, as a rule, low. This is because (1) all the deoxidizers used had also the property of combining with copper, and (2) of the remarkable rate in which the conductivity of copper drops when small amounts of impurities are alloyed with it. The amount of oxygen dissolved in copper during the process of melting is a variable quantity and is distributed throughout the whole mass. It is, therefore, practically impossible to add the deoxidizer in such a way as to eliminate oxygen completely without, at the same time, alloying it to a certain degree with the copper. Accordingly, the conductivity of the resultant product was a matter of accident. In the laboratory sometimes good results were obtained, but they were hard to duplicate and the transfer to the foundry was always a disastrous experiment.

The problem was the finding of a deoxidizer without affinity for copper at time melting point of the latter so that it could be added in excess with impunity.

While carrying on the work of the isolation of the pure element boron, the lack of affinity of this element for copper manifested itself. Boron has, at the melting point of copper, a great affinity for oxygen, nitrogen, etc., and was thought to be an ideal substance for deoxidizing copper. Pure boron can be produced in large quantities and is inexpensive for certain uses based on its electrical properties. For casting copper, however, its price would probably be too high.

In the course of the boron studies, an amorphous powder had been secured which contained as essential impurity only a certain percentage of oxygen and which was termed "boron suboxide."‡ Obviously for the purpose of eliminating oxygen from copper without introducing any impurity, capable of alloying with copper, this boron suboxide would be as good as pure boron or perhaps better on account of its being obtained in form of a very fine powder. Therefore this substance was used in the first experiment. The very first attempt was successful. A perfectly sound bar was obtained with a conductivity of 94%, when 0.1% of the weight of the copper was added. Further experiments showed that the amount of boron suboxide could be reduced to 1/30% and also that the addition of a large excess, say 1%, did not diminish the conductivity or change in any way the mechanical properties of the cast copper.

Here was a method which could be put into the hands of any foundryman and which would always give good results provided the copper (ingots or scrap) melted down was pure metal.

A further simplification, however, was introduced into the process. The reduction of boric anhydride of magnesium gives a product containing magnesium borate, boric anhydride and boron suboxide. While the last one is the active agent, the first two are harmless. The presence of boric anhydride and magnesium borate is even an advantage, as the addition of a larger mass of material makes the operation easier. Also the boric anyhdride would probably dissolve the copper oxide and bring it to the surface as copper borate. It is therefore unnecessary to isolate the boron suboxide. It is sufficient to grind up the above mixture into coarse grains and use an amount of it which contains the necessary amount of boron suboxide.

Foundry practice at present is to add 1 to 1½% of this material, which is equivalent to 0.08 to 0.1% of boron suboxide. The properties of the material obtained are as follows:

The electrical conductivity obtained can be as high as 97½% if the copper melted down is perfectly pure. In the foundry, where the scrap copper which is melted down cannot always be very carefully selected, a conductivity of 91 to 95% is obtained and a guarantee of 90% is given.

The resultant casting is readily machined. The mechanical properties are as follows:

Tensile strength, 24,350 lbs.; elastic limit, 11,450 lbs.; elongation, 48.5%; reduction in area, 74.49%. Castings are being made of all shapes and sizes with no more difficulty than in the case of brass. Sand and iron molds can be used and for standard articles the latter are preferred.

The use of this cast copper lies in two different directions in (1) replacing forged copper and (2) replacing alloys of copper. The gain in conductivity allows a reduction in bulk and thus a saving in material. Castings are much cheaper than forgings.

It is interesting to note that in spite of the fact that cast copper has had lower conductivity than forged copper, in many cases cast copper has been used instead of forged copper. This is due to the fact that a chance is given to eliminate riveted, screwed or soldered joints, whereby a number of poor contracts are avoided. The elimination of joints often insures, too, a better operation.

The cost of the boron added is small; at the present prices of magnesium and boric anhydride the cost per pound of copper is less than ¾ ct.

The success with "boronizing" pure copper, as it is now called in the foundry, has suggested new lines of work, which have been taken up lately, such as (1) the addition of boron to different copper alloys, and (2) replacing the "poling" operation [the addition of carbon, in a reverberatory furnace, by stirring with green wood poles.—Ed.] in the process of refining copper by "boronizing."

*Abstract of a paper before the 18th general meeting of the American Electrochemical Society, Chicago, Oct. 13-15.

†Research Laboratory, General Electric Co., West Lynn, Mass.

[‡See Eng. News, Nov. 4, 1909, p. 499.—Ed.]

The New Insulator "Bakelite."*

With the incorporation of the General Bakelite Co., in New York, and the Bakelite Gesellschaft m. b. H., in Berlin, an interesting invention enters upon its real commercial career. The original paper describing it was read by Dr. L. H. Baekeland on this subject, before the American Chemical Society. More than a year has elapsed since, and considerable progress has been made on the practical side of the question. A brief, up-to-date description of "Bakelite" is not out of place.

"Bakelite" is a new substance, which, in its different forms, offers the advantages of hard rubber, Japanese lacquer, celluloid and in many respects excels the properties of these products. It is not merely a mixture of a so-called "compound" like so many rubber, shellac, or other resinous compositions, but a well-defined chemical substance of specific properties; it thus adds an important member to the industry of plastics.

In the synthesis of "Bakelite," we have a more recent instance of a laboratory reaction, which seems to run along lines parallel to those of the delicate physiological changes which occur in plant life; it has some relation to the subtle process which in the Japenese lacquer tree engenders the substance known under the name of Japanese lacquer. Up till now the latter has been a product of limited applications, and an article of luxury, on account of its excessive price, and scant supply. Henceforth a new material has become available which can be manufactured in practically limitless quantities and at a price which allows a wide range of uses.

The laboratory method is an improvement on nature's process, not only because the reaction is quicker and less expensive, but the resulting artificial product is decidedly more resisting to chemical and physical influences.

Dr. L. H. Baekeland, the inventor of this process, has a record of more than a quarter of a century of research in the field of pure and applied chemistry. To those outside of the chemical profession he is more particularly known through his inventive commercial achievements in the industry of so-called gas-light photographic papers, of which "Velox" is the best known representative.

*From an article in the December issue of the "Journal of Industrial and Engineering Chemistry," published by the American Chemical Society.

The word "Bakelite" was selected as a simple trademark for the longer and less expedient chemical name oxybenzylmethylenglycolanhydride.

For the layman it is somewhat startling that in the formation of "Bakelite" two strong smelling liquid substances (carbolic acid and formaldehyde) should, under certain well-defined conditions, react chemically upon each other and solidify to a transparent amber-like solid substance entirely devoid of odor and taste.

The Bakelite process involves the utilization of three distinct and well-defined varieties designated "Bakelite A," "Bakelite B" and "Bakelite C." "Bakelite C" is the final product, where as "A" and "B" are the transition products, which enable us to mold or otherwise apply the material before its final condition.

"Bakelite A" is the initial raw material and exists in liquid, pasty or solid condition. Every variety of this, if heated at a sufficiently high temperature changes into "B," then into "C." All varieties of "A," whether they be liquid, pasty or solid, are still soluble in alcohol or acetone or in caustic soda, and behave as true resins.

Solid "A" is characterized by the fact that it is solid at ordinary temperatures, but melts if moderate heat is applied and stronger application of heat makes it infusible and insoluble, by transforming it into "B" or "C."

"Bakelite B" is an intermediate solid product. It is neither so hard nor strong as "C," and may be easily mistaken for Solid "A," but it is different from the latter on account of its insolubility. Furthermore, it is infusible, although the application of heat may temporarily soften it, without, however, bringing it into fusion. Solvents do not dissolve it, but some of them, like phenol or acetone, may soften it or swell it, without bringing it into solution. "B" is specially characterized by the fact that although it is infusible, it will soften under the action of heat and then will mold and weld together if pressed in a hot hydraulic press. The latter fact differentiates it clearly from "C."

"Bakelite C" is the final product, resulting from the application of heat to "A" or "B," and may be considered as a chemical polymer of "B" resulting from a multiple molecular grouping. It is no longer a resin, because it lacks all the chemical characteristics of a resin, although physically it may resemble amber. In pure form, and if made from the first member of the phenol group, its chemical formula is represented by $C_{45}H_{38}O_7$.

The various uses of "Bakelite" will be better understood if we mention summarily some of its properties.

The final product, "Bakelite C," is infusible and can resist temperature of 572° F. (300° C.) or over. It is insoluble in all solvents, and can withstand strong chemicals, oil, hot water, steam, etc. All this in conjunction with its dielectric properties make it an excellent electrical insulator. It can be compounded with various filling materials and shaped or molded, with great accuracy to articles of unusual strength. It can be sawed, turned and polished.

It can be used to impregnate wood and other porous bodies, rendering them harder and more resisting to chemical and physical influences. Or it can be obtained as transparent as glass, or colored to suit special requirements.

It can be purchased at a reasonable price, the latter varying with its different qualities.

Although "Bakelite" is stronger and harder than celluloid or hard rubber, it lacks the unusual flexibility of both of these plastics. Rods or plates made of it, or its compositions, are somewhat flexible, but considerably less so than celluloid or hard rubber. On the other hand, it withstands incomparably better, high temperatures and in general all chemical and physical influences, and has the further advantage of not being attacked by solvents nor by most chemicals. It does not emanate sulphur like hard rubber, nor nitrous products like celluloid, which have a very disturbing influence in some electrical applications. If heated in a flame, it does not suddenly catch fire like celluloid nor melt like rubber; it simply chars, then burns with difficulty.

During the act of hardening, which engenders the final product, there is a shrinkage of about 2 per cent. in diameter, or in length. This shrinkage can be lessened by the judicious incorporation of filling materials, and if the latter be used in large amounts, the decrease in volume can be reduced to such a point as to make it hardly perceptible. Its specific gravity is about 1.25.

Although the preparatory work connected with the industrial side of the process has been going on with strenuous application since 1907, it was thought advisable not to jeopardize everything by a too hasty, broadcast introduction, before each industrial use had been studied for a sufficiently long time, on a practical commercial scale. This conservative way of proceeding is not always followed by those who are not sufficently aware of the enormous distance that exists between a laboratory conception and the practical utilization thereof.

In the meantime, "Bakelite" has been used continuously during the last two years, especially for electrical purposes, while undergoing the test of time and the critical observations of every-day practice under the eyes of specialists. This work has been conducted on a sufficiently large scale to remove all doubts as to the practical side of the question.

"Bakelite" electrical insulators as well as pump valves, and other molded goods are now obtainable from several licensees, and some electrical manufacturers have begun the practical impregnation of coils, dynamos, motors, etc.

The General Bakelite Co. will limit more specially their attention to the chemical side of the process manufacturing the raw materials, just far enough that the users thereof can limit their attention to the mechanical side of the problem. A factory plant is being equipped now at Perth Amboy, N. J., but in the meantime the manufacturing is being carried on in Yonkers. The offices of the General Bakelite Co. are at 100 William St., New York City.

Repaving the "Loop" District in Chicago with Creosoted Wood Block.*

(With full-page plate.)

By WILLIAM W. MARR,† M. Am. Soc. C. E.

For years this great city, though building upwards of a hundred miles of permanent pavements each season in the outlying sections, did nothing toward improving the conditions in its central business district. The streets in the heart of Chicago or the "Loop" were paved for the most part from 15 to 25 years ago with granite blocks. These blocks were laid on a rolled stone foundation which has since entirely disappeared by reason of improper repairs after numerous openings. The durability of these pavements has been remarkable, but, on account of their worn and irregular surface, the terrible jolting to passenger vehicles and the roar of constantly increasing traffic has become unbearable.

The Board of Local Improvements, after making an extended inspection tour of various large cities of the country, has taken up this problem and has entered upon a campaign which it is hoped will ultimately give Chicago the best system of pavements in its business center that the science of roadmaking and art of construction can accomplish.

The creosoted wood-block pavement has been tried out under various conditions in Chicago, and has given such general satisfaction that it seems now to be only a question of time when it will supersede granite block where noise is a factor, asphalt for the more highly traveled and

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†Assistant Chief Engineer of Streets, Board of Local Improvements, Chicago, Ill.

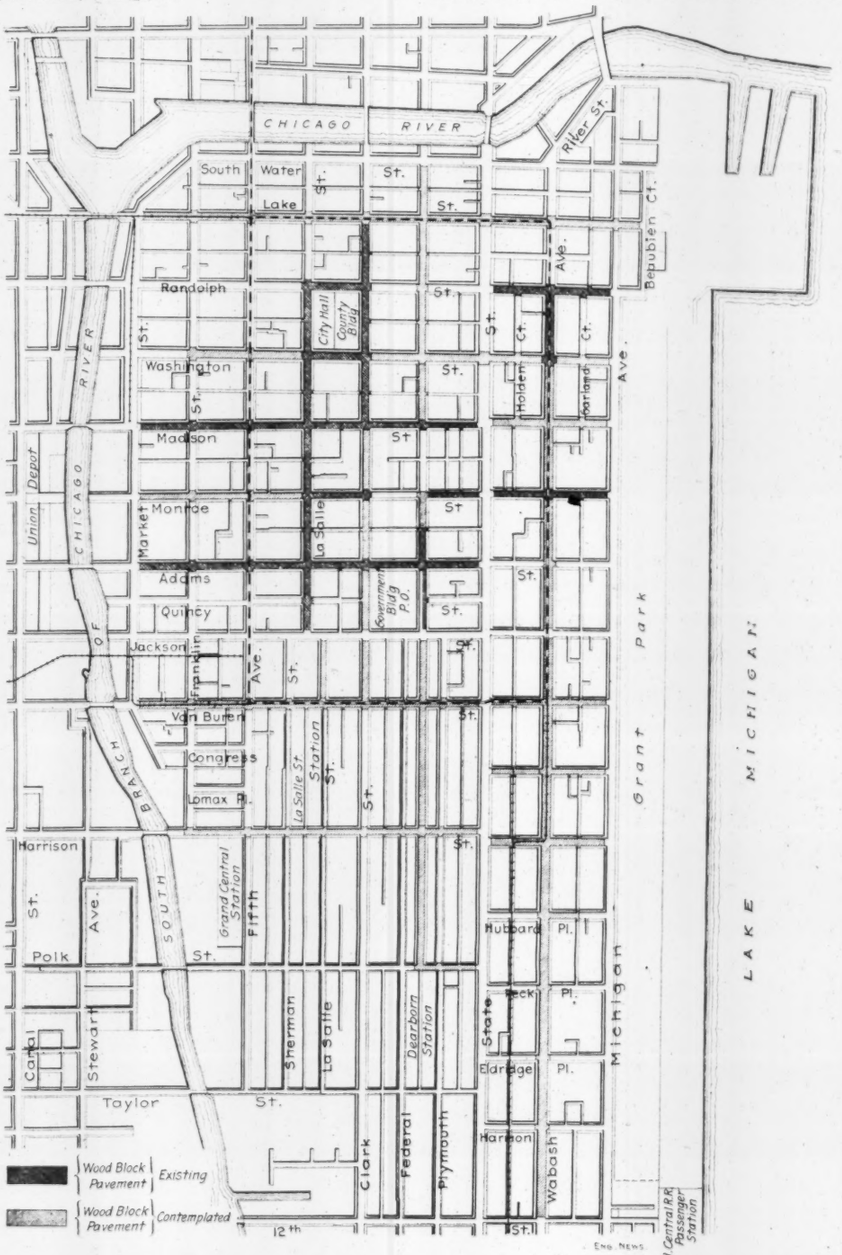

FIG. 1. MAP OF THE BUSINESS DISTRICT OF CHICAGO, SHOWING PRESENT AND PROPOSED WOOD-BLOCK PAVING.

FIG. 2. MAKING THE SAND BED.

FIG. 3. LAYING THE BLOCKS.

FIG. 4. CULLING IMPERFECT BLOCKS AND ROLLING.

FIG. 5. LAYING THE SAND FILLER AND TOP DRESSING.

REPAVING THE "LOOP" DISTRICT IN CHICAGO WITH WOOD BLOCKS. VIEWS ON LA SALLE ST.

better class of residence streets, and brick on the more progressive of the small business streets.

It is the object of the writer to point out as many as possible of the causes of failure in this class of pavement, and to show how some mistakes may be avoided and better results may be obtained.

During the last year five contracts have been completed for wood-block pavement in the "Loop." These were (1) Randolph St. System, comprising Randolph St. from State St. to Michigan Ave., and Wabash Ave. from Washington St. to Randolph St. (5,700 sq. yds. at $3.16); (2) the City Hall System, comprising Clark St. from Lake St. to Madison, LaSalle St. from Randolph to Madison St., Randolph St. from LaSalle to Clark St., and Washington St. from LaSalle to Clark (10,600 sq. yds. at $3.35); (3) Monroe St. from Dearborn St. to Michigan Ave. (5,200 sq. yds. at $3.35); (4) LaSalle St. from Madison St. to Jackson Boulevard (6,300 sq. yds. at $3.42); and (5) Adams St. from State St. to Market (5,300 sq. yds. at $3.45).

All of these pavements were laid on 8 ins. of Portland-cement concrete (1:3:6 mix) and 1 in. of sand bed. The blocks were of long leaf yellow pine, 3¼ ins. wide, 4 ins. deep and from 5 to 10 ins. long. The joints, except a strip 18 ins. wide along all railway tracks, gutters and around all manholes and expansion joints where tar was used, were filled with fine sand and the surface was covered with ¼-in of coarse (torpedo) sand. Expansion joints 1 in. wide of paving pitch ("the direct result of the distillation of 'straight run' coal tar") were built longitudinally along each curb and transversely at intervals of 25 ft. except in the Randolph St. system, where they were spaced 50 ft. apart. The blocks were treated with creosote oil, 16 lbs. per cu. ft. of timber. Following is the specification for the oil used:

The oil shall be a pure coal-tar product, free from any adulteration. It must not contain any petroleum oil or any product obtained from petroleum, and shall contain not more than 5% of matter insoluble in benzole and chloroform. No oil obtained wholly or in part from water-gas tar or oil tar will be accepted.

The specific gravity of the oil shall be at least 1.10 at 25° C.

The oil shall be subject to a distilling test as follows: The apparatus for distilling the creosote must consist of a stoppered glass retort having a capacity, as nearly as can be obtained, of 8 oz. to the bend of the neck, when the bottom of the retort and the mouth of the offtake are in the same plane. The bulb of the thermometer shall be placed ½-in. above the liquid in the retort at the beginning of the distillation, and this position must be maintained throughout the operation. The condensing tube shall be attached to the retort by a tight cork joint. The distance between the thermometer and the end of the condensing tube shall be 22 ins. and, during the process of the distillation, the tube may be heated to prevent the congealing of the distillates. The bulb of the retort and at least 2 ins. of the neck must be covered with a shield of heavy asbestos paper during the entire process of distillation, so as to prevent heat radiation, and between the bottom of the retort and the flame of the lamp or burner two sheets of wire gauze each 20 mesh fine and at least 6 ins. square must be placed. The flame must be protected against air currents.

The distillation shall be continuous and uniform, the heat being applied gradually. It shall be at a rate approximating one drop per second, and shall take from 30 to 40 minutes after the first drop of distillate passes into the receiving vessel. The distillates shall be collected in weighed bottles and all percentages determined by weight in comparison with dry oil. When one hundred grams of the oil are placed in the retort and subjected to the above test, the amount of distillate shall not exceed the following:

Up to 150° Centigrade	2%
Up to 210° Centigrade	10%
Up to 235° Centigrade	20%
Up to 315° Centigrade	40%

The contractor shall deliver to the Board of Local Improvements an affidavit setting forth that all oils used for treating the blocks for this contract are oils obtained wholly and entirely from coal tar and free from all adulteration, and that there is no material not a product of coal tar mixed with it.

The writer has been directed to prepare estimates for wood block pavement on practically every street in this "Loop" district not already paved with wood block, or under contract, amounting to about 83,250 sq. yds. This is shown in the accompanying map, Fig. 1.

It is not to be supposed that all of this will be agreed to by the property owners who must pay for it. Some will surely be abandoned at the public hearing, as there are streets in this list on which the pavements are still serviceable and the only objection to them is their noisiness. It is remarkable that objections to improvements in this district, where land is so valuable, are so strenuous and so bitter, but it is true that every paving proposition is contested more here than at any other part of the city. One reason is that owners are almost always represented by attorneys or agents whose one idea seems to be to save their clients from any cash outlay, no matter what the merits of the case may be.

An idea of the value of property in the "Loop" district may be had from the valuation of the land and buildings in the block bounded by Washington, Clark, Madison and LaSalle Sts., recently made by the Board of Review for taxation. This block is a fair average of value in this district. The total valuation is $10,951,244, of which $2,020,251 represents the value placed upon the buildings. This corresponds to a square foot value of $102, or a front foot value of $8,360, figuring all four sides as frontage.

If a man with 25 ft. frontage, whose house and lot is valued at $4,000, pays $100 for an asphalt pavement every 15 years, it represents an outlay of 27 cts. per front foot per year, neglecting interest, on a valuation of $160 per front foot of property. By direct comparison on that basis, the property in "The Loop" could stand the cost of a creosoted-block pavement every six months.

Paving in a district where there are greatly congested traffic conditions always brings forth many problems in the way of doing the work with as little damage as possible to the public, as well as to the various large interests which are always involved. During the course of construction of these pavements last year many meetings of officials and interested persons were held for the purpose of making or changing plans that might expedite the work. The greatest cause of delay was the fact that the various public-utility corporations had work to do in the streets before the paving could be done, and as space was limited only one corporation could, as a rule, work at one time. Many unforeseen difficulties were constantly arising which could not be avoided, even though all the men that could work in the streets at once were employed. Every minute of time was utilized, including nights and Sundays. The fastest work was done on Monroe St. from Dearborn St. to Michigan Ave., a distance of three blocks. This street was started on July 20, 1910, and finished on Aug. 4. The slowest progress was made on Adams St. from State to Market St., five blocks (one block from Dearborn St. to Clark St. had been previously paved by private contract). This street was started Oct. 8, 1910, and finished Dec. 5. The reason for the slow progress was that the paving contractor and all others doing work in the street were, by way of experiment, required to finish one side of the street before the other side could be torn up at all. This proved a failure and it was shown that it took nearly twice as long to do the work as it would have taken if the whole street had been torn up at once.

After the various public-utility corporations had completed their work and left the street to the paving contractor, the building of new catch basins and sewer inlets was started. Creosoted-block pavements, perhaps more than any other, require good and adequate drainage for the double reason of avoiding slipperiness, by keeping the pavement clean, and of avoiding the disintegrating effects of water on the blocks themselves. In order that a wide distribution of traffic should be encouraged and slipperiness avoided, the crown of these pavements is not over 8 ins. at its maximum on roadways of 60 ft. or over 7 ins. in 48-ft. roadways. This necessitated numerous sewer inlets on account of the fact that the whole "Loop" district is level. This pavement becomes very objectionable when the crown is sufficiently great to make it slippery. Where the foundation is reliably strong enough to maintain its original position, the crown should never be more than enough to carry the water with reasonable speed to the gutter.

The rate of fall in the gutters is not less than 6 ins. to 100 ft. This is an important consideration in level territory where it is necessary to work between very restricted limits, as for instance in a narrow street occupied by car tracks such as Adams St. from State to Market St., which has a roadway of only 38 ft. The street railway occupies 16 ft. and this leaves but 11 ft. on each side to pave. It will be readily seen that numerous sewer inlets are necessary if a high crown is to be avoided and a rate of grade of 6 ins. to 100 ft., in the gutter, is maintained.

The underground work in the "Loop" district is so crowded that to build even an inlet connection with the sewer is in many cases well nigh impossible, and the fact that the sewers in this district are so small and so flat makes it almost imperative that some sort of a catch basin be built at each inlet. These sewers were designed many years ago without contemplating or providing for the enormous growth that has occurred since. Chicago has, as yet, done practically nothing to control the operation of the companies that use the space under the streets and is consequently paying very dearly for this neglect.

The roadbeds for these streets were prepared in the usual manner by grading and rolling with a ten-ton, three-wheeled roller. In a great many instances it was necessary to abandon the use of the three-wheeled roller and substitute a two-wheeled drum or an asphalt roller on account of the numerous manhole covers which obstructed the free action of the roller. In such cases the iron manhole covers were removed temporarily and the brick work of the manhole was broken down a few inches below the subgrade so that the roller was able to pass over. While this method has its limitations and is not wholly satisfactory, it is believed that very good results were obtained considering the difficulties encountered.

The concrete for the foundations was mixed in a machine and hauled to its place in dump carts. It was then spread and tamped to its proper elevation. Considerable difficulty was had in keeping the public from running over the newly laid concrete and marking it up with their foot prints. The concrete had been made rather wet, and in this method of machine mix a great many spots showed an excess of mortar on the surface. It was necessary after the concrete had set to go over it with a pick and chip off the little ridges and then to fill the hollows with more mortar.

A great deal of care was taken to get uniformity in thickness and smoothness of surface in the sand bed, but in spite of all precautions some places were found to have more than the proper amount of sand and some few places no sand at all. When no sand could be put in over the concrete as laid, enough of the surface of the concrete was chipped off to admit of at least ½-in. of sand. Where too much sand was used trouble invariably followed. This may have been due to the fact that the filler was also sand, but, from the observations of the writer, it is not safe to use much more than 1 in. of sand, no matter what the filler is, as it undoubtedly has a tendency to move under the action of heavy traffic.

In one instance the large amount of sand was due to an error in setting the stakes for the concrete foundation. At this point the stakes were set and the concrete was laid at night and the shoulder of the pavement was set too low, making a depression in the surface of the finished concrete. When the sand was dumped over this spot and spread out to fit the street railroad tracks on one side and the gutter on the other side it was not noticed that so much sand existed in the center, and it might have escaped attention entirely had it not been for a manhole cover which had to be raised. Upon investigation it was found that the sand bed at this point was something over 3 ins. thick and extended each way from the manhole cover for about 20 ft. On account of the Knights Templar conclave it was necessary to hurry the street to completion and so the surface of the concrete was not brought up. The paving was placed over this spot at its proper grade, but within three weeks after the street was thrown open to traffic a noticeable depression in the surface took place and practically every block over this entire area showed bad cracks. This happened in

front of a new building which is nearing completion and all of these blocks will be removed as soon as the building is finished.

Where sand is used as a filler, some provision should be made for draining the sand bed. Otherwise floating blocks and washouts near the sewer inlets may be expected. One case of this arose on Monroe St., just east of Dearborn St. The catch basin had leaked and had been stopped up pending repairs, so that a heavy rain in the meantime caused water to collect and stand for some time over this catch basin and the adjacent pavement. Some time afterward it was discovered that the sand bed had "started," that the blocks were floating and a large amount of sand was being pumped up through the joints to the surface of the pavement by the action of traffic.

Mr. Charles K. Mohler, Consulting Engineer, recently suggested that we use a coarse sand for the bed in order to reduce its tendency to shift under the action of traffic. This, the writer believes, is a very excellent suggestion, but he also believes that coarse sand has a greater and more far reaching source of value in that it would facilitate drainage. By spreading fine gravel around a suitably constructed sewer inlet the water of the bed could percolate through and drain off without carrying the sand with it. On examining the sand bed, exposed when openings were made, on two occasions recently the sand was found to be thoroughly saturated with water and no rain had fallen for some time previously. Both the places were near sewer inlets, which fact of course may have had some bearing on the case. Still it is believed that the whole bed must have had more water in it than it would have had if proper means of draining had been provided.

The importance of competent inspection and "culling" of the paving blocks can hardly be overestimated. Unless a very uniform quality of material is used failure is sure to follow. For this reason the writer has thought that a few illustrations of the commoner causes for rejection of blocks on the street might be of interest.

Fig. 9 is a photograph of a block cut from too rapid growth timber. The number of annual rings being less than six to the inch measured from the center of the heart, the block must, under our specifications, be rejected. Fig. 6 is a photograph of a block with a "red heart," showing evidences of decay so that it is to be rejected. Fig. 10 is a photograph of a block with a "wind shake." This is a dangerous block and is always rejected. Fig. 7 is a photograph of a block with numerous fine cracks known as sun cracks, the result of exposure to the weather. This block would be rejected if it was the same on both ends. But by turning it over the other end is found to be sound as shown by Fig. 8 and is therefore accepted and used.

Many blocks on being split for the purpose of making mitres or closures show white on the inside and appear to have received very little treatment. This is a cause of a great deal of complaint from those who are anxious to see the best result obtained and who are not familiar with the reason for blocks having this appearance. As very great numbers of blocks are treated at one time, it is not reasonable to suppose that a few blocks could have received a less pressure and treatment than the balance have had, so it can safely be assumed that these blocks which do not show so great a penetration as the rest are simply incapable of taking the oil on account of their pores being already filled with resin. Blocks of this sort have never given any trouble and are consequently never rejected.

Quite a little trouble has developed in the accidental use of blocks of less than the standard depth. The variation is not usually over ¼-in. and the discrepancy does not make itself apparent until after the pavement has been open to traffic. Rolling and cross rolling with a much heavier roller than is commonly used seems to be the most feasible means of overcoming this difficulty.

As uniformity in the character of material used is most important, one competent inspector should pass on every block in a well defined area, which area should be made a matter of careful record in order that the inspector may feel his responsibility and that he may later be held to account if defects develop.

It is a mistake for any city to have more than one standard width of blocks, because when it becomes necessary to make repairs it is very difficult to do good work unless new blocks of the same width as the original blocks are available.

The amount of oil which should be forced into a cubic foot of timber should vary with the size of the block, the kind of timber, the filler and the conditions of traffic under which it is to be used. The writer is of the opinion that 10 or 12 lbs. per cu. ft. in blocks of 3¾ × 4 ins. cross section for heavy traffic streets is ordinarily ample, though where sand is used for a filler 16 lbs. might be advisable on account of the increased liability of water absorption. Where cleaning of the streets is infrequent more oil should be used than where cleaning is regularly and thoroughly done. Of course, the amount of oil which should be used depends on local conditions of atmosphere and temperature. For any one place as Chicago, for instance, it should be regulated by traffic conditions, by the thoroughness and frequency of cleaning, by the amount of sprinkling it receives, by whether it gets the sun or is continuously shaded as by high buildings or an elevated railroad, by the degree of perfection in its drainage, by the success with which water can be kept from the bed, and by the care with which it is to be maintained.

The most serious objection to creosoted-block pavement rises through what is known as "bleeding" of the blocks. When this occurs the oil which is used in treating the wood comes to the surface in the same manner as the resin comes from a pine knot exposed to the summer sun. If pitch has been used as a filler, and especially if any excess pitch has remained on the surface of the blocks, the condition of the street on a warm day is insufferable. As this class of pavement is used largely on streets where the surrounding property is valuable great damage results. The oil and tar are carried into the residences, hotels and office buildings, ruining fine carpets and rugs, as well as the clothing of those who cross the street. The storm of protest reaching the Board of Local Improvements from those injured by such conditions during last year and the early part of this year, caused it to abandon pitch as a filler and to substitute fine sand.

Bleeding is a serious problem, well worth consideration, and from its very nature it is evident that each street will produce its own peculiar features and require its own solution. Bleeding can come from a too resinous wood, from improper seasoning, from an excess of oil, or from an excess of paving pitch which combines readily with the preservative. Too resinous wood should be rejected at the plant and proper seasoning insisted upon.

When the life of the pavement is of paramount importance, a good paving pitch should be used to fill the joints. The melting point should not be so high that the material is very brittle at ordinary temperatures. It should be applied very hot and all excess of pitch should be quickly removed from the surface of the blocks. For long life, the wood should have a heavy treatment of oil for the conditions under which it is to serve, varying in amount for long-leaf yellow pine, for instance, from 20 lbs. per cu. ft. of timber as a maximum to 10 lbs. as a minimum, depending on the considerations above noted.

Fig. 6. Red Heart.

Fig. 7. Sun Cracks.

Fig. 8. Reverse of Sun-Cracked Block.

Fig. 9. Too Rapid Growth.

Fig. 10. Wind Shake.

FIGS. 6 TO 10. COMMON IMPERFECTIONS IN WOOD PAVING BLOCKS.

If bleeding occurs, sand or limestone screenings should be spread over the pavement and, if this does not do all that is desired in the way of taking up the excess of pitch and oil, the pavement should be thoroughly cleaned at the first favorable opportunity with hot shovels. One or two cleanings will probably be all that is ever necessary.

The writer finds no reason to favor a treatment of over 16 lbs. per cu. ft. for Chicago conditions. West Taylor St., laid in 1904, shows no signs of failure from either rot or wear, and the conditions under which it has served have been most unfavorable. The traffic is very heavy; the roadway is narrow (38 ft.); it has a double-track street railway; it is in a very poor district and is always more or less dirty with garbage and refuse of all sorts. The wood in this pavement is long leaf yellow pine and was treated with 12 lbs. of oil per cubic foot. The blocks were laid on 6 ins. of Portland-cement concrete and a 1-in. sand bed. Expansion joints filled with coal-tar pitch were built 1 in. wide along the curbs and transversely ½-in. wide at intervals of 100 ft.

The writer had a block taken up from a point half way between the car track and curb on this street on Dec. 1, 1910, after six years' wear, and found that it measured 3.9 ins. in depth on one end and 3.85 ins. on the other end. Fig. 11 is a photograph of this block split in half and the end of a new block of the same depth as the old one was when first laid. The wear is inappreciable, and the wood fibers seem to have been uninjured by the many six and eight-ton loads passing over it. Out of curiosity the writer had an analysis made of the wood in this block to determine the amount of oil per cubic foot of timber in it. The result of this analysis was 19.62 lbs. per cu. ft. As there is no way of knowing what the block contained originally, the experiment proves nothing but it is interesting to note that a block having all the physical characteristics of an average specimen of yellow pine timber should, after six years of use contain 19 lbs. from what was originally a 12-lb. treatment. It is the belief of the writer that timber will take treatment in direct proportion to its requirements.

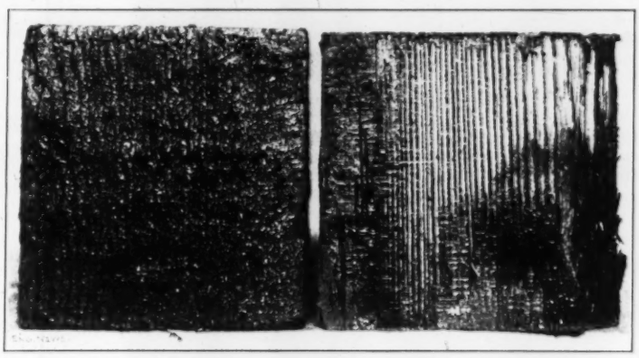

FIG. 11. A WOOD PAVING BLOCK AFTER SIX YEARS' WEAR.

The writer believes that more careful attention to details of construction will add greatly to the life of the pavement and that the tendency is to use too much oil, a large percentage of the cost of which might much better be put into maintenance, on the old theory of a "stitch in time," and with an accompanying reduction of the probability of bleeding.

Outside the street-railway tracks, blocks in Chicago have always been laid at an angle of about 45° with the center line of the roadway. This is more a matter of custom than anything else, and the writer believes there are several good reasons why block should be laid at right angles to the center line of the pavement. This method would avoid the costly and unsatisfactory miter at curbs, car tracks, and at manhole covers. Better work could be done with a poorer class of workmen and a great deal of material could be saved. The argument of calks in horses shoes starting the joints, or the contention that wheels traveling over and parallel with the longitudinal joints will open them, does not seem to have much foundation in fact. Where blocks are laid at an angle of 45° to the center line of the street no block should be permitted in making a closure which has a side less than 4 ins. in length. This requirement was enforced in the construction of all the new pavements put down in the loop, but it necessitated a large loss of material. This loss could not well be avoided except by running the courses as suggested above.

The blocks in these pavements were laid closely together and frequently driven into nearly straight lines with a sledge. After a section had been laid and culled a man with an iron bar would go along and pry the blocks in each row tightly together, substituting a longer block for one where the opening was made. After thorough rolling, culling all bad blocks and breaking all joints, sand was spread over the surface to a depth of about half an inch. It is very remarkable that while the blocks had been laid very closely together and forced by means of the iron bar before referred to into close contact in a transverse di ection that within a few moments after applying the sand all joints would show plainly openings at least one-eighth of an inch and a great many one-fourth of an inch wide. This must have been due to contraction of the wood following the application of cool damp sand to the warm blocks.

It took a great deal of labor and pains to fill the joints full with sand, it being necessary to go over the whole area three or four times with brooms to accomplish it. Sand for this purpose should always be heated and used hot. Heating will pay for itself as all this brooming can be done away with when the sand is really dry and hot. After the fine sand had completely filled the joints, the coarse torpedo sand was spread over the pavement to a depth of about ¼-in. and the street was thrown open to traffic.

The rolling of the blocks was found to be a most important factor in the smoothness and evenness of the finished pavement. It was done on the last three contracts with a drum roller of about five tons weight—3,925 lbs. on the small wheel and 7,480 lbs. on the larger while loaded with man, coal and water. The wheels were 41 ins. wide. The writer believes this too heavy for a first rolling, as large numbers of good blocks were broken by it, and that it was not as heavy as desirable for final surfacing. The rolling was always done in at least two directions and, where there were no car tracks, in three directions. The roller used broke a good many blocks wherever the sand bed happened to be a little more than one inch, or where a block rocked on a projecting ridge of concrete or a loose piece of broken stone. It is believed advisable by the writer to provide for two weights of rollers, one a light baby steam roller, or even a hand roller, to give a first settlement to the blocks and to prevent their being broken by the second rolling, and the second a roller of at least ten tons weight for the final settling. The evenness of the surface resulting from this method would more than compensate for the additional cost of the rolling.

In paving Wabash Ave., on which there is an elevated railroad (the "Loop" line), the vibration transmitted through the supports of the structure to the pavement, caused the sand filler which had been spread over the surface to work down through the joints and under the blocks. After work had progressed some little distance on one side of this street it was noticed that the blocks around these pillars were too high and accordingly they were lowered. When it became necessary to lower them the second time the cause of the trouble was discovered. Afterward tar was used to fill the joints around all posts and no further trouble was experienced.

To make a pavement stand up alongside street-railway tracks and around manhole covers, has long been recognized as one of the most troublesome problems with which the road builder has to deal. It has been the observation of the writer that while the vibration of the rail along street railways is an important factor in the destruction of the adjoining pavement it is the *combined* action of water and vibration that does by far the greatest part of the damage and that, wherever tracks and pavement drain rapidly and thoroughly, comparatively little trouble is experienced. He believes too much stress cannot be laid on this point. Chicago's street railways have in the past two or three years been entirely reconstructed and the opportunities for studying this question are many. The new rails are imbedded in a heavy concrete foundation which extends about 18 ins. out from the rail. This reduces vibration to a minimum, and yet, wherever any water is held, the adjoining pavement goes to pieces as quickly as it ever did. On the other hand, where the drainage is good, there are as yet no signs of failure.

In paving LaSalle St., the granite blocks (brow paving) along the rails, which had been put in by the railway company, were by mistake allowed to remain, and quite a stretch of the new creosoted block pavement had been laid before the matter came to the attention of the writer who at once directed the contractor to have the granite blocks removed. On account of property rights, and the question of who should bear the expense, the contractor made a demand on the railway company to come and remove its property. By the time the railway company got men on the work, all the west side of the street in the block, from Madison St. to Monroe St., was paved. The granite blocks, however, were duly removed, and the contractor set about filling in the space with creosoted block. As the granite was much deeper than the wood blocks that took its place, it was decided to bed the latter in lean mortar. The work was finished in this manner, and is a better job than has been obtained in the regular way.

Next year, the writer will provide in the specifications that the pavement along street railways shall be laid flush with the rail, making no allowance for settlement, and then rolled away from the rail so that no part of the paving is ever above the rails and that before the filler is applied the blocks for a space of 1 ft. from the rails be taken up and relaid on dry mortar carefully and accurately to the level of the rail. If this is done it will be possible to get a more uniform surface, more uniform strength, more perfect drainage and, through the greater rigidity of the mortar bed, an easier transition from the rail to the less resistant surface of the pavement. The joints along the brow will be filled with paving pitch to provide for expansion.

Paving around manhole covers should be done in the same manner, taking care that the mortar bed does not form a dam and interfere with the drainage of the sand bed. No allowance should be made for probable future settlement or wear of the pavement. These are unknown quantities which cannot be predetermined. The wear on a creosoted-block pavement, leaving out the jarring over the manholes, which is reduced to a minimum by making them flush with the surface of the pavement, is very little for a long time. When wear does occur it is a small matter to make necessary repairs. On the other hand, if the manhole cover is set too low the surface is never smooth, no matter how many repairs are made.

The writer favors sand over mortar as a bed for blocks because it permits of a smoother surface; it permits of drainage which will be necessary in time no matter how carefully or with what material the joints are filled; it admits of greater latitude in making repairs, that is, it is not necessary to close up the street after repairs have been made and good work can be done with less skilled men, and because it affords some protection to the foundation.

Expansion joints should be made to fit the re-

quirements of each particular case and should be made on a sliding scale of width and frequency, depending on the temperature at which the blocks are laid and tightness with which they are driven together. The present width of the transverse joints in the pavements laid last summer averages about ⅜-in. wide, while they were originally ⅞ to 1½ ins. wide and 25 ft. apart on all but the Randolph St. system. On two occasions there was trouble from swelling and heaving of the blocks. Both these "explosions" occurred in the same cross section of pavement one on the north and the other on the south side of Randolph St., opposite an alley near Michigan Ave. The omission, through mistake, of the longitudinal expansion joint, was largely responsible for the accidents.

A Comparison of Electric and Gasoline Driven Blast-Hole Drills.

By B. G. COPE.*

The many tests which have been conducted by a number of quarry people in the past two years have amply demonstrated that the method of large holes and heavy charges is the most practical proposition for producing broken stone in quarries where the face of the quarry is 12 to 15 ft. or deeper. One of the quarrymen's greatest worries is producing the stone fast enough for the capacity of the plant. The well drills have solved this problem and eliminated the bad feature and a big item in the expense of production, as it requires on an average 50% less linear feet of drill hole and a considerable less quantity of explosive besides saving delays in waiting on available stone for the crusher. In some of the larger quarries as many as ten well drills have been installed dispensing entirely with the large tripod outfits.

In ascertaining the kind of power most suitable for operating blast hole drills of the well driller type, on a given quarry work, much depends on the power used in the quarry and its adaptability and convenience for supplying the motive power on outside portable outfits. The drill should make from 60 to 64 strokes per minute, at which speed it will drill the maximum number of feet per hour. Changes in speed of the driving engine or motor make no material difference with most ordinary quarry machinery and is probably unnoticed. With the well-type driller, however, a change of speed makes a great deal of difference; it not only decreases the cutting speed but throws the drilling cable out of adjustment as the cable, properly adjusted when running at 60 strokes per minute, is not of the right tension when reduced to 40 or 50 strokes; therefore to drill rapidly it is necessary to have an even, regular power as the slacking of power every five minutes 15% to 20% cuts down the drilling rate at least 25% to 30%, and figuring the time lost during the ten-hour run, it will soon pay for the fuel of an independent power plant on the machine, especially if this be a gasoline engine.

Electric power for operating blast hole drills of this character is satisfactory under very favorable conditions; in other words, if the power supplied to the drill can be constantly maintained without a marked degree of fluctuation of voltage, it gives an ideal service in every respect. But in a big majority of cases the operation of electric motors on churn drills is not entirely satisfactory as a great many strokes of the tools are lost, due to the dropping of voltage, which is caused by starting the various quarry machines in the average quarry outfit, the average distribution lines being inadequate for close regulation with alternating current. It is not always convenient or apparently does not justify the installation of a separate transformer for each drill, so that the line for the drill is usually taken off at any convenient point with the result that the speed of the drill changes as the driller is moved about, due to the varying voltage at different points on the distribution line.

The company with which the writer is associated has furnished many electrically driven outfits and they have all been satisfactory to the customers. Some have been installed drawing the current from lines where the fluctuation of current was scarcely noticed; with others the fluctuation was very pronounced. While the customer was satisfied and, in his opinion, the drill was running perfectly, yet from our experience with a large number of electric plants under favorable and unfavorable installation, and with gasoline and steam power, it was quite evident to us that the electrical driven machines working under unfavorable conditions would have shown a much larger earning capacity had they been driven by a power which would have maintained a constant and uniform speed.

It is a difficult matter to convince the owner of an electrically operated quarry plant that motors are not always best to use on a drill. They are such a decided success on all other classes of machines around a quarry that he can hardly appreciate that a drill is vastly different in its requirements. He usually insists on motor-driven machines, though he will not always go to the expense of securing favorable conditions. There is scarcely an objection to this kind of power when once properly installed, for the maintenance is very small. The stringing of the wires to the point where power is to be used covers the only expense necessary in its installation, and in most cases this is very small. Motors for this work must be of some variable-speed type and may be for either direct or alternating current according to the quarry system where the drills are to be used. They must be fitted with resistances and controllers so that the speed may be varied to suit the requirements of the materials encountered. Motors giving the best results on this class of work are belted direct to the driving mechanism of the drill. Back-geared motors are not so well adapted on account of the rapid wearing of the gears, due to the jerking motion and intermittent load on the cable, causing back lashing of the gear, which soon becomes very noisy. It is an entirely different service than when the load is constant, in which event the back geared motor works very well.

The power that gives universal satisfaction, under all conditions and is best for economy and reliability, is gasoline. The average man will shy at the mention of a gasoline engine. He can think only of the troubles with this power which he saw a few years ago. There are good and bad gasoline engines, just as there are good and bad steam engines and electric motors, but the gasoline engines which are being used to-day on drilling outfits are just as reliable in the hands of a man competent to run a piece of machinery, as steam can possibly be, and they have many advantages over any steam engine. With the speed under complete control, with a circulating pump for handling the water for cooling the cylinder, a perfect igniting system and a simple means of adjusting the explosive mixture, gasoline engines are fully as reliable as steam can possibly be. Gasoline engines have given entirely satisfactory service on blast-hole drills. They are absolutely portable and independent of power plants. There are no wires to string or take care of and no alteration necessary other than starting, stopping and oiling—just the same kind and amount of attention that is required in the electric-motor outfit.

An engine of the vertical type is best suited for drilling, as the vibration is in the same direction as the dropping of the tools, whereas with a horizontal engine the vibration tends to rock the drill and to interfere with the stroke of the tools, thus detracting from the efficiency of the drill. They may be made strong, compact and substantial.

Records have been established in a number of limestone quarries by drilling more than 7½ ft. per hour of 5¾-in. hole. This gives this class of drill a place which was not thought of a few years ago. In Engineering News, March 11, 1909, p. 268, a gasoline self-propelling well-drill designed by the writer was noted. This has proven desirable for general use and has helped to demonstrate the practicability of the gasoline drive for drilling.

*Orrville, Ohio.

William Henry Bryan.

By E. D. MEIER, President Am. Soc. M. E.

On Dec. 5 there pased away, in the fullness of his manly strength, William Henry Bryan, Chief Engineer of the Board of Education of the City of Chicago.

Mr. Bryan won this office at a competitive civil service examination last spring. His appointment had been delayed until Nov. 28, and on that day he entered on the duties of his office with his characteristic cheerful energy. Just one week later, after a day of strenuous work at his desk, he retired as usual, but to a sleep that knew no waking.

Wm. H. Bryan was born Aug. 14, 1859, at Washington, Mo., and was the son of Capt. Archibald Bryan, a pioneer steamboat man, from whom he inherited a fondness for mechanism. One of his ancestors was the famous Daniel Boone of Kentucky. Young Bryan was sent to the country schools, but spent his vacations on steamboats, mastering in turn every duty from roustabout to master. Entering the preparatory department of Washington University, St. Louis, in February, 1876, he joined the freshman class of the School of Engineering in the fall, and there came under the inspiring influence of that engineering enthusiast, Prof. Chas. Smith. Mr. Bryan graduated in 1881, with the degree of M.E. His vacations were utilized in learning telegraphy and other railroad practice in the shops of the Missouri Pacific R. R.

His first work was as a general assistant erecting engineer and salesman with Frank H. Pond. Next he was made local manager of the George F. Blake Co. Then he became Secretary of the Pond Engineering Co., and in 1889 was appointed Secretary and local manager of the Heisler Electric Light Co. of St. Louis, which was then developing a system of long distance series incandescent lighting. In 1891 he went to Chicago as Manager of the Western Branch of the Yale & Towne Co. Since 1892 he had practised as a consulting mechanical and electrical engineer in St. Louis, and has been gradually but steadily gaining recognition and prominence by his straightforward honest methods of carrying on his practice.

Some of the principal works with which he had to do were the water-works of his native town, the power plants of the Imperial Light, Heat & Power Co. of the Coliseum, of the Grand Leader, of the Eli Walker Building, and of Ferguson & McKinney.

He joined the St. Louis Engineers' Club in 1884, serving four years as Secretary, three years as Vice-President and one year as President. He became a member of the American Society of Mechanical Engineers in 1891, and since 1906 has been an active and influential member of its Meetings Committee. In that position he was mainly instrumental in inaugurating and conducting a system of local meetings in St. Louis. He was also a member of the American Society of Heating and Ventilating Engineers, of the St. Louis Railway Club, of the Mercantile Club, of the American Water Works Association, and Secretary of that Association's Committee on Depreciation, and President of Washington University Association.

A close student, a keen observer, an untiring worker, he found time for many professional papers and addresses, covering steam power, smoke abatement, heating and ventilation, water-works, Western river steamboats, street railways, etc., including also ethical, commercial and historical questions of particular interest to the engineer.

He was married in 1885 to Miss Mary Ruge, of Washington, Mo. His widow, two sons, three daughters, his aged mother, two sisters and three brothers survive him.

His loyalty to his friends, to his profession and to scientific societies, his rugged honesty, his kindness of heart, plain speech and devotion to duty, endeared him to all who knew him, and inspired his St. Louis colleagues to apply to him the epitaph framed by the great English bard:

"His life was gentle, and the elements
"So mixed in him that Nature might stand up
"And say to all the world, 'This was a Man'!"

ENGINEERING NEWS

A Journal of Civil, Mechanical, Mining and Electrical Engineering

Published every Thursday by

THE ENGINEERING NEWS PUBLISHING CO.

220 BROADWAY, NEW YORK

BRANCH OFFICES

CHICAGO: 1636 Monadnock Block
WASHINGTON, D. C.: Home Life Building
SAN FRANCISCO: Monadnock Building
RUDOLPH MOSSE, BERLIN AND HAMBURG, GERMANY
Z. P. MARUYA & CO., Ltd., TOKYO, JAPAN

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Twenty-five years ago a number of appliances were in extensive use which involved the use of water from city water-supplies to develop power. At that time water under pressure was practically the only generally available power for small motors. Electric motors were still in the future and so, for that matter, was the general distribution of electric current. The gas engine also was in its infancy, and the gasoline engine was unknown.

The most extensive use of water for power purposes was probably for hydraulic elevators. The elevators were generally of low lifts and slow speed, and at the time of which we write a great many such elevators were in use. Originally, the installation of these power-developing devices, hydraulic elevators, water motors, etc., was encouraged by water companies and municipal water departments. It was thought to be good business to encourage the use of water in this way. Many of these appliances were installed on a flat-rate basis, and superintendents of waterworks were frequently ignorant of the amount of water such devices consumed.

With the increasing demand for water, however, and the growing scarcity of sources of supply, as well as the demand for much better quality in the water furnished, the tendency has long been toward the disuse of such wasteful devices and to confine water-supply systems to their legitimate purpose of distributing water for use as water. We are therefore surprised to learn that in some New England cities hydraulic elevators using direct pressure from city mains still continue in use. We learn it, however, from the published announcement that their use is to be discontinued. In Springfield, Mass., the Board of Water Commissioners has announced that at an early date the furnishing of water for running elevators will no longer be permitted. In Worcester, Mass., as a result of a threatened water famine it has just been announced that elevators taking water from city mains will be cut off at an early date.

The strange thing is that this action should have been delayed all these years. A city's water-supply distribution system is not and ought not to be considered a system for power distribution. It is a wasteful way of using water to put it to such a purpose. The cities are extremely few and far between which can afford any such waste of their public water-supplies.

We commend to those of our readers interested in waterway improvement, two papers printed in the current issue which were read at the recent annual convention of the National Rivers and Harbors Congress held at Washington this month. One of these papers is by General Wm. H. Bixby, Chief of Engineers; the other is by Mr. F. A. Delano, M. Am. Soc. C. E., President of the Wabash Ry.

Many of our readers will recall that the "slogan" of those who have been promoting the Lakes to the Gulf deep waterway scheme has been "14 feet through the valley." But both General Bixby and Mr. Delano present convincing reasons why a channel of such a depth would be no more economical as a transportation route than a channel of 8 or 9 ft. depth. In fact transportation on the deeper waterway would be more expensive when the greater cost of its construction was taken into account. And as Mr. Delano shows, the cost of making and maintaining a channel is as much a part of the cost of water transport as the cost of grading the roadbed and laying the track is part of the cost of railway transport.

We have already called attention in these columns to the fact that depth of channel is not at all the controlling economic factor in river transport that it is in ocean or lake transport. The arguments of Gen. Bixby and Mr. Delano present still further reasons why the agitators for unlimited Government expenditure on deep channels are leading the public astray.

There is, however, still a further reason why deep waterways are not as economical for inland transport as waterways of moderate depth. That reason, in brief, is the added cost of terminals for deep draft vessels compared with shallow.

As has been hitherto pointed out in these columns, the cost of transportation by either rail or water at the present day is in the majority of cases more influenced by the terminal costs than by the cost of hauling between terminals. Both Gen. Bixby and Mr. Delano point out that if inland water transportation is to be revived, modern efficient piers and docks and warehouses must be provided, so that freight may be safely and cheaply handled at the beginning and end of this journey. The annual interest and maintenance charge on the investment in these terminals and the cost of operating them is just as truly a part of the cost of water transportation as the wages of station agents and the repairs of station buildings is part of the cost of railway operation.

Evidently, then, if water transportation is to be made cheaper than rail transportation it will not do to make waterway terminals too expensive. Every engineer familiar with dock and pier construction knows how rapidly the cost of such work increases with every foot increase of draft of vessels that are to be taken care of.

But the waterway enthusiast may argue that the cost of these waterway terminals will be paid by the municipalities anyway so that the river steamboat men might as well strike for the deeper channel. It will be a good while, however, before the towns along the Mississippi and its tributaries will undertake the extensive and expensive river front improvements which all now agree are necessary if the steamboat business is to be revived on these waters. And if piers and docks must be built for boats of 14 ft. draft, there will be few towns in the Mississippi valley, we fear, that can afford at all the large expenditure which will be necessary.

The City of Los Angeles is building a water-supply aqueduct 240 miles long with a capacity of some 260,000,000 gals. of water per day. Only a tenth of this water is at present needed for distribution in the city, leaving 230,400,000 gals. available for other purposes. Further, at various points along this conduit large amounts of water power can be developed and the city is already committed to the idea of developing and marketing this power.

We print in this issue the engineers' recommendations to the people concerning the disposal of the surplus water, and of the hydro-electric power. It may be said that these matters are matters of business and economics rather than engineering; but we think it a fine thing that engineers are taking the lead in dealing with these matters. Particularly worthy of notice is the way in which the problem and proposed solutions of it have been presented to the public. The engineers' recommendations as to the municipal policy to be pursued have been presented before public meetings held two or three times a week during a period of some two months. At these meetings citizens and representatives of various associations have been asked to express their views and to criticise the plans proposed by the city's engineers. It is reported that neither attendance nor discussion has been lacking in these open forums.

In building an aqueduct with a capacity to furnish five times the present water consumption, the city has looked to the necessities of the distant future. At the same time, the financial needs of the present must be met. If only water enough for the city's immediate needs, over and above the old supply, were to be brought down the aqueduct, only a tenth of the aqueduct capacity would be employed but the water users or the city taxpayers would have to carry the whole burden of fixed charges on the conduit, the total cost of which is set at $26,750,000. Further, if the aqueduct were used to only one-tenth its capacity, it would be impossible to economically develop power from its flow. On the other hand, the surplus water cannot be brought down from the mountains and simply turned loose to find its way to the ocean, as serious land damages might be caused. It is, therefore, proposed to apply this surplus water to the irrigation of farm lands in the districts adjacent to the city.

It is stated that the amount of water needed per acre for crop irrigation in this section and the water required for household supply when the same area is built up and becomes part of the city are not very different. It is proposed that the land owners receiving water for irrigation shall pay a "bonus" of $50 per acre, in addition to an annual charge of $10 per acre for the service. If all the surplus water were disposed of in this way, the bonuses received would enable the city to pay off 25% of its total investment in the Owens River Aqueduct and its appurtenances, amounting as above stated to $26,750,000. The annual income from irrigated lands if this scheme is carried out, would yield 5% on the remaining $20,000,000.

The city does not bind itself to furnish water perpetually to the irrigators, but reserves the right eventually to take the water for municipal distribution.

At first it might seem that the farmer in paying this bonus was in reality paying for construction which should secure him a perpetual water supply instead of only a supply that will eventually be cut off. A little study of the engineers' figures, as presented, alters the situation. It is stated that the total cost of the aqueduct development will be $26,750,000, including provision for developing electric power and for turning the surplus water aside into agricultural districts, as explained elsewhere in this issue by Messrs. Mulholland, Lippincott and Scattergood. The cost of the electrical development was recently given by the board of consulting engineers as $60 per horse-power at peak load, or $7,200,000 in all. This leaves the cost for water-supply alone at $19,550,000. If the farmers are to have vested rights to 90% of the flow for irrigation, we may tentatively assume that they should pay for 90% of the development, which would be $17,595,000, and this for the 135,000 acres proposed to be irrigated would be about $134 per acre.

Manifestly, it would be poor policy for the city to lose control of its water-supply system by bestowing rights on the users of a 90% surplus. The "bonus" proposed, therefore, is about half the

cost per acre that would be involved if the irrigators assumed the whole burden of construction cost and obtained thereby a perpetual right to the supply.

But it may be asked what will happen when the water is taken from the irrigated land? For one thing, the city will have expanded, the outlying areas will have changed their character and the value of the land will have increased to urban figures, so that some at least of the farmers whose irrigation supply is cut off will sell their lands for building lots. This gain in value, due to the extension of the city's suburbs will be reached all the quicker by having a water-supply at hand to be turned into the mains of the streets as they are laid out.

The amount of power which can be developed at four different points along the aqueduct ultimately will amount to 64,000 HP., and by the design of regulating reservoirs, a peak load up to 120,000 HP., can be taken care of. This is 141% of the present electric-power peak load in the district, where the power could be marketed, so that there promises to be an entire readjustment of the electric-power situation when the aqueduct is completed.

Of course, it is not proposed to develop all of this power at first, but the aqueduct is being so designed and built that as the market increases the number of generating stations can be increased without reconstruction of the aqueduct to secure the full.

The problem here is whether the city should take over the small-customer service of the present power companies in the district, leaving to these companies the supply of current for electric railways, which promises eventually to absorb the present capacity of these companies, or whether the city shall enter into active competition with these power companies, duplicating their plants and service and bidding for their business.

The alternative of selling power to the existing companies in large blocks for distribution and resale seem not to have been considered here, the trend of public opinion being against such a policy. It is believed that it would perpetuate constant interference of the electric companies in city politics and bring about the undesirable condition of having a number of the city's best citizens with interests conflicting with those of the people as a whole.

It will be apparent that if the sale of surplus water for irrigation and of water power for electric generation is carried out successfully on sound business principles, the Los Angeles water supply conduit will rank as one of the most profitable enterprises of great size ever undertaken by a municipality.

The fact that Los Angeles is seeking in this large progressive way to utilize its great water supply for irrigation and power as well as for domestic use, is a great object-lesson to other American cities. It seems almost unbelievable—the manner in which cities have been tied down and hampered to prevent them from utilizing and selling water-power developed as an incidental in the creation of a water supply. We know of no reason why the taxpayers who are the stockholders of the municipal corporation have not the same right to have their business handled in a businesslike way as the stockholders of any other corporation.

It is not too much to say that during the past few years the failure of municipal government in San Francisco has been effectively counterbalanced by the conspicuous successes of municipal government in Los Angeles. And the success has been attained through the zeal and efficiency and public spirit of its citizens. Foremost among these is the man to whom must be given major credit for the broad conception of the aqueduct project and for carrying it out on progressive lines, Mr. William Mulholland, now Chief Engineer of the Aqueduct and Superintendent of the Water Department. Mr. Mulholland attained his present responsible position by sheer ability and efficiency. His tact and diplomacy and executive ability have been as important in carrying the enterprise to its present stage of successful progress as his skill in engineering.

The Army Engineers' Plan for Raising the Wreck of the "Maine": The Design of Cofferdams for Very Deep Water.

Ever since the U. S. Battleship "Maine" was sunk in Havana harbor in 1898, projects for raising and removing the wreck have been under discussion. The most ambitious of these projects, which was brought forward half a dozen years ago,* proposed to make the vessel into a floating museum for exhibition at cities along the Atlantic Coast after she had been raised and repaired. Engineers were engaged by the promoter of this scheme to make plans for a cofferdam to enclose the vessel, so that she might be laid dry and repaired; a prospectus was prepared showing the enormous profits that would be reaped and the public was invited to subscribe for the stock. Apparently, the public did not feel as confident as the promoter concerning the enormous profits, as few subscriptions were received, and the enterprise was therefore abandoned.

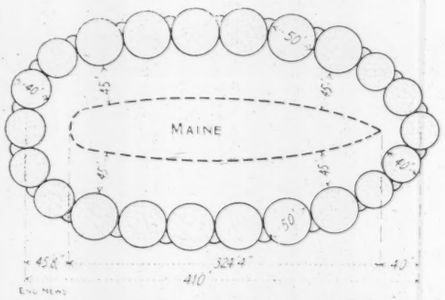


Fig. 1. Diagram Plan of Cofferdam Made Up of Cylinders of Steel Piling; to be Built Around the Wreck of the "Maine."

(Reproduced from Engineering News of Oct. 20.)

One feature of this widely advertised enterprise was the agreement that the remains of the United States sailors who were lost when the "Maine" was wrecked should be recovered and restored to their friends for decent burial. It is probable that that proposal, made by the promoter of that company, is partially responsible at least for the widespread public sentiment that the United States Government should raise the wreck of the "Maine" in order to recover any remains of those who were carried down with the wreck. This idea has been urged upon Congress from time to time, and finally resulted in the passage at the last session of Congress of an act appropriating $300,000 for raising the wreck of the "Maine."

It is worth while noting that it is sentimental considerations only that impel the Government to raise the "Maine." The wreck itself is valueless. It will cost more to remove it in any case than the scrap it contains will be worth. Even if the vessel could be raised and so repaired as to be restored to its condition prior to the explosion, it would be obsolete for naval use as the result of 15 years' progress since she was built. It will be apparent that the Government could not consent to the vessel's use for exhibition purposes; and public sentiment generally would undoubtedly oppose any such use of the vessel, even if she had been raised by private enterprise.

There are, therefore, only two objects in raising the wreck of the "Maine." The first is to remove an obstruction to navigation in Havana harbor, which is also a perpetual reminder of one of the most unfortunate incidents in our naval history. The other object is the purely sentimental one of recovering any remains which may still exist in the wreck of those who perished at the time of the explosion. Were it not for this latter object, the sensible thing to do would be to pursue the course that would be used with the wreck of any ordinary vessel, namely, blow her to pieces with dynamite and dredge out the wreckage. But inasmuch as it was sentimental considerations which caused Congress to pass the act above referred to, it is essential that the vessel be first of all made accessible before her destruction is attempted.

It may be said that there is another object in the raising of the "Maine," namely, to see what further light may be obtained upon the cause of the explosion that wrecked the vessel. It is doubtful, however, whether, after the lapse of 12 years, with the corrosion that has taken place and the burial of the parts in mud, any very conclusive evidence will be found as to the cause of the explosion, even when the vessel is laid dry.

The widespread agitation which we have referred to has had another result. It has set engineers all over the country scheming out plans for raising the "Maine." A large number of these plans were presented and considered by the Board of United States Engineers, on whom was laid the responsibility of carrying out the work ordered by Congress.

We published the report of this Board substantially in full in our issue of Oct. 20 last. In that report were given the controlling reasons which led the Board to the adoption of the cofferdam plan rather than any scheme for lifting the wreck bodily from its present position on the mud bottom of the harbor. It will be generally conceded, we believe, that the conditions set forth by the Board make the choice of the cofferdam plan necessary. It is not a mere engineering question as to the cheapest and best way to float the vessel or to remove it. As Congress was governed by sentimental considerations in passing the act, sentimental considerations must also govern in the choice of methods, and the "Maine" must therefore be laid dry first of all, lest by any other method of work the ship might not be intact when exposed.

Turning, therefore, now to the cofferdam plan devised and adopted by the Board of United States Army Engineers, it has seemed to us that some discussion of this plan would be of general interest to engineers. So far as we can recall, no such cofferdam, in such a depth of water on such a bottom, has ever been built anywhere. The problem is to surround the wreck of the vessel, about 325 ft. in length, lying in 37-ft. depth of water, with a dam which shall be tight enough and strong enough to enable work to be safely carried on under its protection.

This dam must be self-sustaining. There is no way of bracing it to resist the water pressure behind it by struts against its interior. The borings published on page 425 of our issue of Oct. 20 show that for a depth of 18 to 20 ft. the bottom of the harbor is a soft semi-liquid mud. Below that for some 25 to 30 ft. there is a soft blue clay. The building of a dam which will withstand a head of 37 ft. of water on such a foundation is a task so unprecedented that it may well excite the interest of engineers generally. The dam must not only be self-supporting and safe against the pressures to which it is exposed, but it must be capable of complete removal after it has served its purpose. It must, moreover, be able to support more or less superposed loads. Upon it must be built some sort of working platform from which can be carried on the work of unwatering the area which it encloses and from which afterwards men and materials can be transferred to the interior for work upon the wreck.

The plan which the Board of Army Engineers has adopted was fully described in our issue of Oct. 20, and is shown in Fig. 1 herewith, reproduced from that issue. Briefly described, the plan is to sink around the wreck a series of large cylinders of interlocking steel sheet-piling. These cylinders are to be 50 ft. in diameter along the sides of the wreck and 40 ft. at the bow and stern. The sheet-pile cylinders are to be sunk to a depth of 70 ft. from the surface, which means that their lower ends will have about 33 ft. penetration in the bottom.

After these cylinders have been sunk, a dredge will dig clay from shoals in the harbor and deposit it in hopper scows. These scows will be towed over to the cofferdam, and their loads of clay will be deposited in the cylinders until they are full. The Lackawanna steel piling is to be

*Eng. News, Dec. 8, 1904.

used for the cylinders and a considerable part of the piling has already been rolled and shipped by the Lackawanna Steel Co.

The best precedent for this peculiar type of cofferdam is the cofferdam at Black Rock, near Buffalo, N. Y., which was described and illustrated in our issue of Oct. 8, 1908. The Black Rock cofferdam is made up of square cells, instead of circular, 30 ft. on a side. The depth of water at the site of this cofferdam is only 15 ft. as a maximum, and the bottom is said to be fine sand, gravel and hardpan. It will be seen at once that the task at Havana is vastly more difficult than that at Buffalo. A dam in soft mud to withstand a head of 37 ft. is a far different proposition from a dam built in water only 3 to 15 ft. in depth.

It will be of interest, we believe, to present a computation of the stresses in the 50-ft. steel sheet-pile cylinders proposed for the "Maine" cofferdam. Consider, first, the stresses that exist after the cylinders are filled with clay and before the area enclosed by the dam is laid dry. As already related, the cylinders are to be filled with clay which will be dropped from dredges through the water contained in the cylinder into the soft mud of the harbor bottom. This cylinder may be compared to a grain-bin or a standpipe, and we may proceed to compute the bursting pressure due to the weight of the soft clay tending to open the cylinder at the joints between any two of the interlocking piles.

If the clay with which the cylinders were filled were a perfect liquid, we could at once compute the bursting pressure by the ordinary rules for water pressure. Admittedly, the clay is not a perfect liquid, yet under the circumstances in which it is placed it seems certain that it will be so soft and will flow so readily that it will act very much like a liquid in producing horizontal pressure. After considering the formulas in common use for pressures on grain-bins and on ordinary retaining walls, it seems to us that under the conditions existing in these cylinders at Havana it will not be safe to assume a pressure due to the contained mud in these 50-ft. cylinders of less than 80% of the full pressure which would exist if the mud were a perfect liquid.

It must be remembered that soft clay mud, such as these cylinders will contain, has a very flat angle of repose, and if proper allowance is made for its character, the ordinary retaining wall or grain-bin formulas would give stresses nearly or quite as high as the figure we have adopted.

The saturated clay with which the cylinders are to be filled weighs about 120 lbs. per cubic foot. At the harbor bottom, in 37 ft. of water therefore, the pressure per square foot against the side of the cylinder will be 120 lbs. × 37 × 80% = 3,552 lbs. The seawater surrounding the cylinder, however, weighing 64 lbs. per cu. ft., exerts its full liquid pressure, in opposition to the internal pressure of the clay. This water pressure at the harbor bottom is 64 lbs. × 37 = 2,368 lbs. per sq. ft. Subtracting this from the internal pressure due to the clay filling we obtain 1,184 lbs. per sq. ft. as the net internal pressure upon the cylinder at the harbor bottom. On the cylinder 50 ft. in diameter this internal pressure will cause a tangential stress of $\frac{1{,}184 \text{ lbs.} \times 50}{2}$ = 29,600 lbs. per lineal foot of joint, or 2,460 lbs. per lineal inch.

The Lackawanna steel sheet piling which is being used at Havana, has joints with an ultimate tensile strength, we understand, of about 10,000 lbs. per lineal inch. The sheet-pile cylinders, therefore, are apparently strong enough to hold their clay filling until the cofferdam is completed and the process of unwatering begins.

Let us now consider the stresses after the interior of the cofferdam is pumped out. The interior bursting pressure due to the clay filling remains the same and the external water pressure is the same on the side of the cylinder next the sea. On the inner side of the cofferdam, however, the water pressure is removed and there is, therefore, a maximum bursting pressure at the bottom of the cofferdam cylinders on the inner side amounting to 3,552 lbs. per sq. ft.

This pressure produces a tangential stress on the joints of the steel piling on the line A-A, Fig. 3, equal to 88,800 lbs. per lineal foot of joint, or 7,400 lbs. per lineal inch.

As the ultimate strength of this joint is only assumed at 10,000 lbs. per lineal inch it will be at once evident that the stress contemplated is much too high for safety.

Further, there may be stresses on this joint from other causes than internal pressure of the clay filling. Loads on the top of the pile cylinder due to the working platforms and anything placed upon them will be carried by the piles as long columns and the tendency of the piles to bow outward when so loaded will produce stress upon the joint. Again, the piles cannot be driven exactly vertical. If the foot of a pile inclines slightly inward as it goes down, the joint between it and the piles on either side will be under compression. If the foot of the pile inclines slightly outward, the joint will be under an initial tension before the filling of the cylinder with clay begins. This initial tension must be added to that caused by the pressure of the clay filling to obtain the total stress upon the joint.

It is proper also to inquire into the strength of the joint which has to carry these very heavy stresses. Fig. 2 shows a cross-section of this joint. Present knowledge of the strength of this joint is based on the results obtained on narrow pieces of the piles, about 2 ins. wide, which are put into a testing machine and pulled until the joint opens and separation occurs.

In the piles used for the Black Rock work, the tests showed an average strength of 9,700 lbs. per lineal inch. An even higher strength is claimed for the piles to be used in the "Maine" cofferdam, and 10,000 lbs. per lineal inch is, we understand, guaranteed. This is a most excellent record, highly creditable to the manufacturers of the piling. Such a tensile strength is many times as great as there is any need for in almost any place where steel piling is used.

In the "Maine" cofferdam cylinders, however, such a high tensile strength is, as shown above, absolutely essential to the safety of the work. It is important to inquire, therefore, whether the strength of the joint shown by tests of small sections of piling, is a thoroughly reliable guide to the actual strength of the joints between successive piles in the completed cylinder?

Examine the details of the joint shown in Fig. 2. In order that the joint shall open, the curved arms m, m must be bent and at the same time the inclined contact surfaces of the jaws, S, S must slide upon each other. Sliding must also take place between the backs of the jaws and the inner sides of the curved arms m, m, on the contact surfaces K, K. The less the friction between these surfaces, S, S and K, K, the greater the bending stress upon the arms which a given pull upon the joint will produce. In other words, the condition of the contact surfaces will apparently greatly influence the strength of the joint.

Now will the joint between the actual piles as driven be stronger or weaker than the joint between small test specimens? The piles will quickly be rusted in the salt water in which they are driven, and this will make the joint stronger.

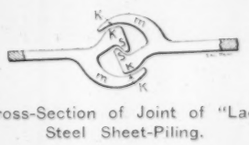


Fig. 2. Cross-Section of Joint of "Lackawanna" Steel Sheet-Piling.

On the other hand, the whole joint will be doped with the soft slippery clay and mud with which the cylinder is filled. Perhaps this is gritty enough to increase the strength of the joint. Possibly it is greasy enough to reduce the strength. In any event, it would seem worth while to try a fair sized section of the joint, say 6 ins. to a foot long in a testing machine and slush it well with clay before pulling, and see how the strength of a joint so treated compares with that now assumed.

We have considered so far the bursting pressure on the interior of the cylinder and the strength of the cylinder to withstand it. Let us inquire now concerning the strength of the cylinder as a whole to resist the horizontal pressure of the water on the outside of the cofferdam after the interior is pumped out. The computation of the water pressure is, of course, exceedingly simple. The 50-ft. diameter cylinder in water 37 ft. deep has an area of 50 × 37 = 1,850 sq. ft. The pressure varies from zero at the surface to 2,368 lbs. per sq. ft. at the base. Thus the average pressure on the cylinder is 1,184 lbs. per sq. ft., and the total pressure is

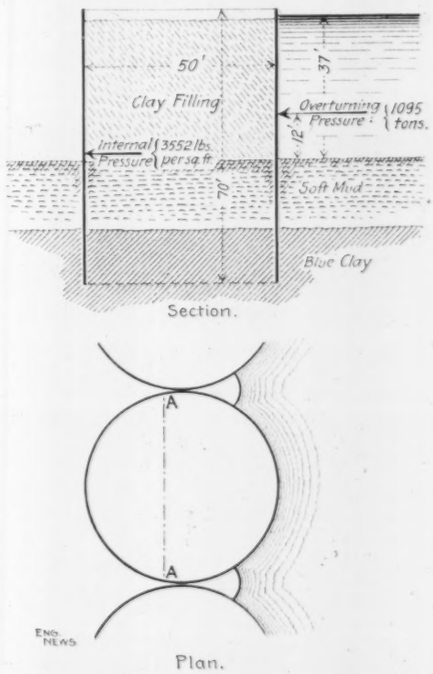


Fig. 3. Vertical Section and Plan of 50 Ft. Steel Sheet-Pile Cylinder for "Maine" Cofferdam

2,190,400 lbs., or 1,095 tons, which may be considered as concentrated at a point two-thirds the distance below the surface, or 12 ft. from the bottom. The average overturning pressure per lineal foot of the whole cofferdam is about 25 tons.

What is the strength, now, of the mud-filled steel-pile cylinders to resist this huge horizontal pressure? The empty sheet-pile cylinder itself, manifestly, could not begin to sustain it. The piles would bend over in the soft mud into which they are driven, slilding upon each other at the joints like the staves of a barrel with loose hoops. The interior filling, however, by placing the joints under tension adds greatly to the strength of the cylinder and in addition has a large resistance of its own. What that resistance is, it is impossible to compute. It depends upon the consistency of the material, and its internal friction. If good gravel were available for filling the cylinders, for example, their strength would almost certainly be ample. On the other hand, if the clay with which the cylinders are filled is slow to give up its water and remains a soft, putty-like, greasy mass, it seems likely that the clay may slowly flow under this heavy pressure and the cylinder may be pushed over until the distortion added to the internal bursting stress will open some joint, allow the clay to flow out and the dam to fail.

For it must be clear that the opening of any one joint of all the thousands in these steel-pile cylinders will mean the immediate failure of a cylinder and the flooding of the interior of the cofferdam. The clay filling of the cylinders will flow if released, we should judge, at least as readily as grain in an elevator bin; and besides if any joint fails, the pressure will quickly open out the sides of the cylinder to right and left on either side of the break, giving a wide opening for the outflow of the clay. Further, when

the clay flows out of the cylinder, the exterior wall against which the water stands will be left unsupported and liable to collapse as soon as the clay support is removed to great enough depth.

It has seemed to us important that the plans for recovery of the "Maine" should be publicly discussed by the engineering profession, for it is a matter which affects the profession as a whole. The work upon the "Maine" is an engineering task without precedent, one which attracts national and even international attention. It will not do, therefore, to take chances with the work. The cofferdam built around the "Maine" must be above all things safe. It would be the worst kind of a blot upon American engineering if this dam were to give way at a time, perhaps, when a hundred or more workmen might be busy on repairs to the damaged vessel's hull. Or a party of inspecting Congressmen, even, might be caught in such a catastrophe.

The Army engineers in charge of the work on the "Maine" have been wise and broad-minded in giving full publicity to the plans they have adopted for carrying out this work. We have undertaken the above discussion of these plans in no spirit of captious criticism, but to the end that any weak or debatable point in the proposed structure may be made secure.

It would be interesting to discuss other possible types of cofferdam which might be used in this location. Many will doubtless suggest themselves to our readers; but careful analysis will show that the task of designing a structure which will be safe and stable on such a foundation and under such a high head of water and which will fulfil all other necessary conditions is far from being an easy one. We turn, therefore, to consider what means can be adopted to increase the strength and safety of the design now adopted.

One method, which is, we believe, contemplated by the engineers in charge, is hooping the steel cylinders near the bottom, where the bursting pressure is greatest. It would be a herculean task, of course—putting a series of steel-wire cables around these big cylinders, passing them through holes cut in the diaphragms by which the successive cylinders are connected and finally making them tight with turnbuckles. All this would have to be done by divers working in 37 ft. of water. Nevertheless it might be possible of accomplishment.

Even if the hooping were successfully done, however, from the bottom up to say a depth of

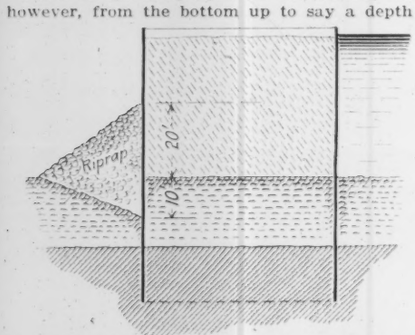


Fig. 4. Section of Pile Cylinder for Cofferdam Reinforced by Mound of Riprap on Inner Side.

20 ft. or so, where the strength of the unhooped joint might be assumed to be sufficient, it would leave the strength of the mud-filled cylinders to resist the horizontal water-pressure still uncertain.

The best plan we are able to suggest to make the cylinders secure against both bursting and overturning is the dumping of a mound of coarse gravel or riprap stone along the inner side of these cylinders, as shown in Fig. 4. A mound of this stone, particularly if it were of high specific gravity, would exert a heavy counter-pressure to resist both the interior pressure of the clay and the horizontal pressure of the water outside. It would take a large amount of stone, of course, but it could be placed and removed at a low cost per cubic yard and the total cost would not be a prohibitive percentage of the entire cost of the work. We know of no other method by which a proper margin of safety for the "Maine" cofferdam can be as readily secured.

Automatic Stops to Prevent Accidents to Trains Running Past Danger Signals.

We publish in this issue a letter describing a recent derailment to an express train on the Delaware, Lackawanna & Western R. R. caused by the engineer running at high speed past a danger signal. Our correspondent, who was a passenger on the wrecked train, describes the accident and then proceeds to criticise the railway company for not having in use some device for automatically stopping a train which runs past a danger signal.

This attitude of our correspondent is a perfectly natural one. It seems to the layman, and even to the engineer who is only casually familiar with railway practice, that there would be no very great difficulty in connecting some mechanism to a danger signal which would automatically apply the brakes on any locomotive that runs past it. Our correspondent outlines, in fact, the essentials of such a device in his letter, and evidently thinks that it would be an easy matter to install such a device and secure thereby additional safety in the movement of railway trains.

As those of our readers familiar with railway matters are aware, this is very far from being a new subject. Automatic stop inventions are almost as old as the art of railway signaling. They have been in use to a limited extent for nearly 20 years past. It is entirely natural, therefore, that the question should be asked, why have the railways not applied these inventions on a large scale?

It is common to hear this question answered by offhand statements that the railway companies are too parsimonious to spend money for safety appliances; that railway officers will not look at a new invention unless it is backed by influence or advanced by graft; that the railways are in a rut of inefficiency and will not make any move for improvement unless compelled by legislatures or commissions.

But before a man with unprejudiced mind accepts such indictments of railway companies and their officers, he will naturally inquire whether these automatic stop inventions will really furnish the increased safety in train movement that is claimed for them. For those of our readers who care for an answer to this question we particularly commend a paper reprinted in this issue from the Bulletin of the International Railway Congress. The paper is written by a German engineer, and reviews the extended investigations into automatic stop inventions which have been made during the past decade on the railways of Prussia and Austria. Investigations similar to those made in Europe have also been carried out in this country by the Block Signal and Train Control Board, created by Congress some three years ago.

This Board had its origin in the popular belief that the railways were remiss in not supplementing their fixed signals with the automatic stop appliances which numerous inventors were proclaiming to be a short and sure road to safety. In the three years during which the Board has carried on its work, however, it has failed to discover any automatic stop which has on the whole seemed to promise an actual gain in railway safety.

In considering the merits of any safety appliance, the question which must always be carefully investigated is whether the new device will create new dangers which may perhaps be greater than those which it is designed to remedy.

For example, many inventors have proposed to supplement the indication of the semaphore beside the track by a signal which is displayed in the cab when the semaphore is at danger. But when such a device is installed, the engine runner will become accustomed to rely on the cab signal instead of the semaphore. Some day it may happen that the cab signal mechanism will become deranged and may fail to show the proper indication when it passes the semaphore at danger; and the engineer, looking at the cab signal instead of the semaphore, may neglect to stop his train. Of course, it will be said that cab signals should be so designed, in conformity with the principles of correct signaling practice, that any defect or failure of the mechanism will cause the danger signal to be shown. The fact is, however, that many inventors have ignored this principle in their devices. The railways have often been criticised, therefore, for not adopting so-called safety devices that would actually produce worse dangers than those which they were designed to obviate.

Our correspondent's letter, elsewhere reprinted, is another illustration of the necessity of expert knowledge as to the conditions of railway operation. He suggests the placing of an automatic brake-applying device at the danger signal. It requires only a moment's reflection, however, to realize that had such a device been in operation it would not have prevented the accident in question. The train running 40 miles an hour would have gone off the track at the turnout curve even if the brakes had been applied as it struck it. In order to stop a train running at 40 to 60 miles an hour, the brakes must be applied far back of the danger signal. It does little or no good to apply them just at the point of danger.

Suppose, however, the brake-setting device were moved back, to a point 1,000 to 1,500 ft. in advance of the danger signal. The device would then operate, it is true, to stop a train running at high speed, but it would also stop all other trains as well. In other words, it would not be possible to move trains at all over this distance of 1,000 to 1,500 ft. when the signal is at danger. This introduces operating difficulties which every railway officer will recognize.

Again, if the automatic brake-setting device is to stop a high-speed train before it reaches the danger signal, it must apply the emergency brake. This, however, is extremely undesirable. As every railway man knows, the emergency brake is for emergency use only. It would not by any means add to the safety of operation if every train which should run past the distant signal when at caution should have the brakes applied with the sudden shock of the emergency.

So we might continue with a list of the difficulties which have thus far prevented automatic stops from coming into general use on railways. The subject is so well presented in the paper reprinted elsewhere, however, that it is needless to duplicate the argument here. That some safeguard against the over-running of danger signals is desirable is already well understood by railway officers. It ought to be better understood by the general public that failure to adopt such devices by the railways is not due to either ignorance or neglect, but because the devices thus far invented and tested for general railway use have not commended themselves on the whole as contributing materially to the safety of train movements.

LETTERS TO THE EDITOR.

A Test of Old Bridge Iron.

Sir: After reading in your issue of Dec. 15 the article on "Condition of Structural Iron After Long Service," I thing the following test of old material may be of interest:

In 1908 a diagonal bar was removed from a lattice-girder on account of a flaw at one of its connections, and a test-piece was cut from the body of the bar about 18 ins. from the end. The girder had been in constant use for 22 years, carrying railroad loads, both steam and electric, and the member in question was directly under a frog, where it was subjected to considerable jar.

The test-piece, 1.5 ins. × 0.295 in., showed the following:

Ultimate strength	48,540 lbs. per sq. in.
Elastic limit	26,880 lbs. per sq. in.
Elongation in 8 ins.	25%
Reduction of area	28.27%

Two additional test-pieces were bent cold under a steam hammer, and bent flat upon themselves; one showing a slight fracture. The material was iron manufactured about 1885.

Howard C. Baird.

149 Broadway, New York City, Dec. 21, 1910.

Standardizing Boiler Tests.

Sir: In the article in your issue of Dec. 15, entitled "Annual Meeting of the American Institute of Chemical Engineers," is a reference to the Committee on Standardizing Boiler Tests. As an item of news supplemental to your account, I will say that the report of the Committee of the Institute stated that this committee had postponed its work, awaiting the appointment of a committee by the Western Society of Engineers and I will say that the Board of Direction of the Western Society of Engineers appointed its committee on Dec. 6.

Very truly yours,

A. Bement,
Consulting Engineer.

2114 Fisher Building, Chicago, Ill., Dec. 9, 1910.

Foundation Pressure on Hardpan: Proposed Rule.

Sir: The question has several times arisen in this bureau as to what pressures under foundations should be allowed on hardpan. No provision for hardpan is made in the Building Code, but it is manifestly unfair to limit the loads on hardpan to 4 tons per sq. ft., which is the maximum allowed under any condition, except where special tests are made.

It is suggested, and is now being considered for adoption, that the allowable load on hardpan may be taken at 15 tons per sq. ft., provided, however, that no such pressures will be allowed except where the foundations go at least 40 ft. below the surface. The proposed rule is as follows:

ALLOWABLE PRESSURE ON HARDPAN.—Where conditions do not otherwise interfere, the allowable pressure per square foot on hardpan under caissons or other forms of foundations may be taken at fifteen tons per square foot, provided the foundations are carried to a point at least forty feet below the curb.

As this is a subject that will particularly interest the engineering profession at large, especially that part of it which is doing work in New York City, I will be glad to hear from any of your readers as to the propriety of the adoption of the above rule.

Rudolph P. Miller, Superintendent,
Bureau of Buildings for the Borough of Manhattan, 220 Fourth Ave., New York City, Dec. 20, 1910.

[What is hardpan? So far as we know, engineers do not have a definite and uniform idea of what hardpan is. The great increase of loading proposed could be misapplied unless a quite positive definition or description of hardpan be added to it. Can such a description be formulated.—Ed.]

Further Information Regarding the Imhoff Sewage-Clarification Tank.

Sir: Mr. Paul Hansen, in your issue of Dec. 15, 1910, in a letter regarding the Imhoff sewage-clarification tank, asks for a brief description of the sludge-drying beds, together with the areas required for them, and also for a comprehensive method to determine the size of the sludge wells.

The sludge-drying bed has a top layer of sand or grit, which, in several plants located in the Emscher district, is formed of the material collected in the grit chamber. Some of it is always lost when digging out the sludge and is, therefore, frequently and easily replaced. The next layer below is about 10 ins. deep, and consists of broken stone or slag from ½ to 4½ ins. in diameter. Below the stone are drain tiles sufficiently close and large to carry away the drainage from the sludge, which drainage occurs almost wholly during the first day. The water is clear and non-odorous.

In the Emscher district, it has been found that, on the average, the sludge becomes spadeable in six days, including rainy days. The water at first drains out easily because of the increase in the size of the pores, due to the expansion of the enclosed gases, that were under 20 to 30 ft. of pressure, when at the bottom of the tank. After the sludge becomes compacted by the escape of the gas, the remainder of the moisture is removed by evaporation at the surface and leaves the sludge with an average water content of from 55 to 65%.

The size of the upper tank, for the mechanical clarification of the sewage, depends on the quantity of sewage that must be held back about two to three hours, so as to allow for the necessary sedimentation into the lower tank. The size of the lower tank, for the biological decomposition of the sludge, must be estimated on the following basis.

The amount of sediment to be collected and held must be computed from the analyses of the sewage or from an experiment. Sufficient space should be provided in this tank to hold the sludge up to the level of the slot at the bottom of the upper tank for such a length of time as the particular sludge needs to "rot out." The length of time depends on the character of the sludge and other conditions to be ascertained for each case. Generally speaking, six months should be sufficient for probably every case, although three to four months have been found satisfactory in some instances. Near the surface of the sludge, the water-content may be assumed at 95% to 97%, near the bottom at 70% to 80%, because the layers of sludge, as they become decomposed, gradually become more compact and granular with less hydroscopic capacity, which corresponds to the degree to which the material has rotted away. Knowing the amount of dry sludge deposited, and estimating its expanded volume due to the moisture content, the storage capacity can be obtained, adding, of course, the additional storage for the time between the sludge dryings.

The letter of Mr. Hansen calls attention, also, to the fact that the Imhoff tank treatment is not itself a complete means of sewage purifications, but merely a preparatory process. This fact, that the Imhoff tank is but a means for removing most of the putrescent and offensive suspended matter in sewage, cannot be too strongly emphasized. It does what the septic tank was at first expected to do, and does it without stench, a most desirable advantage. It clarifies the sewage to a certain degree, but does not purify it. The remaining liquids and the fine suspended particles would, under favorable conditions, set up a putrefaction.

While these tanks give ample purification when their effluents are sufficiently diluted by the water of the stream into which it is discharged, they must be followed by an oxidation process on land, whenever such dilution is insufficient. Most of the Emscher district plants now built have sufficient dilution for their effluents, but I saw one at Holzwickede which, in the absence of such dilution, has a sprinkling filter to secure the necessary oxidation.

Very truly yours,

Rudolph Hering.

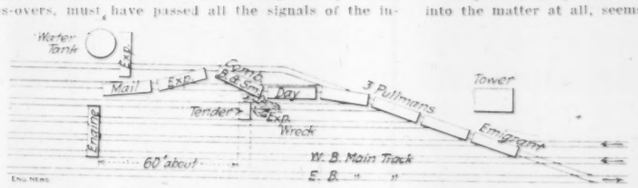
170 Broadway, New York City, Dec. 19, 1910.

The South Orange Derailment on the Delaware, Lackawanna & Western R. R.

Sir: On the morning of Nov. 2, 1910, Train No. 15 of the Delaware, Lackawanna & Western R. R., which left Hoboken at 2.25 a. m., was wrecked at a point about one-half mile west of South Orange Station shortly after 3 a. m. The writer was a passenger on this train and was able to observe the cause and nature of this wreck.

It is the opinion of the writer that the wreck was caused by gross carelessness on the part of the locomotive engineer on the train. Gross carelessness is hardly the word either, as, unless the man was asleep at his post, it seems inconceivable that he would risk his own life by deliberately running past the block signal and the interlocking signals which were set against him.

The train was running westward at something like 40 miles an hour, on the westbound main track. The tracks were set for movements across the whole system of tracks on the cross-overs shown on the sketch herewith, the switch into the South Orange yard also being set for entrance into that yard. By good fortune, there were no cars standing in this yard in the area affected by the wreck. Of course, the train, on entering this system of cross-overs, must have passed all the signals of the interlocking system which would be set against movements in the main track, as these switches could not have been set for the cross-over movements, with the signals set for main track movement, on account of their control by the interlocking machine in the tower.



SKETCH OF DERAILMENT AT SOUTH ORANGE YARDS OF DELAWARE, LACKAWANNA & WESTERN R. R., NOV. 2, 1910.

The train "ran through" the switch at the west end of the trailing point cross-over between the two main tracks, and, taking the facing point cross-over to the westbound siding, entered the yard through the facing point turnout to same. Of course taking these turnouts at so high a speed caused the locomotive to lurch badly, and after entering the yard a short distance it left the track.

The accompanying sketch shows the position of the train after derailment. It seems almost a miracle that with the cars so badly damaged there were no casualties more serious than the scalding and bruising of the locomotive engineer and fireman, no express, mail, or baggage clerks, or passengers being injured at all.

From the appearance of the wreck the engine must have slewed around practically at right angles to the tracks and plowed up the ground with a pile of rails and ties from the track in front of it. The engine finally tipped over, broke away from the tender, and slid up the tracks approximately 60 ft. from the point where the tender was stopped by the pile of material in front of it.

The express car immediately behind the engine was smashed to kindling wood at the point where the tender was blocked. Two other express cars and one mail car were pushed on beyond this tender across the area which was torn up by the locomotive, and were not smashed, but, miraculously, kept right side up and the clerks in these cars were not injured. Also the combination baggage and smoking car, a day coach and one Pullman left the track, and were shoved out into this area where the tracks were torn up, but no passengers, as far as could be observed or learned by the writer, were injured.

My object in writing this is to call your attention to a railway accident which had all the possibilities of a catastrophe with its long list of killed and injured, as far as carefulness or carelessness on the part of the railroad company's management is concerned, and it did not seem to the writer that the mere fact that there were no people killed and none but two employees injured, is sufficient excuse for the wreck not to be mentioned in all the newspapers.

It would seem to the writer that the railway company is deserving of fully as much censure as it would have received if twenty or thirty passengers had been killed and a like number more or less seriously injured.

I do not know whether the railroad company calls the attention of its other locomotive engineers to such an accident as this, as an example of what not to do, or whether they avoid even the publicity of such an announcement to them; but full accounts in, and comments from, the newspapers should be published, the writer thinks, in order to try to avoid recurrence of such accidents. If any people had been killed, there would have been a Coroner's inquest, and the Grand Jury of Essex County, N. J., would have been called on to act. It would seem that the same causes should make the Grand Jury act, even though none were killed.

With inventions which have already been perfected, it is quite possible to avoid the possibility of such an accident as the one above described, especially where, as in this case, the turnouts are protected by an interlocking installation governing switches and signals. Opposite each signal can be placed a device which will turn through an angle with each movement of the signal whether for or against movements of the trains, this device to be thrown through this angle by the same lever movement in the tower that moves the signal, and turn in such a manner as to automatically open a valve on the compressed air train line, which opening of said valve would cause all the air brakes on the train to immediately be set. This same device could also be made to open the valve in the main steam line or steam chamber of the locomotive, causing the steam pressure in the engine to drop down, thus shutting off the power.

The writer is somewhat familiar with devices of this character, and believes that same are patented and on the market for steam railroad companies to buy. With the present development of interstate traffic, it would seem that the Interstate Commerce Commission would insist on installations of such an automatic character for interstate traffic in the same manner as this Commission insisted on the installation of air brakes and automatic couplers on cars and trains engaged in interstate traffic.

The prevailing opinion among people who have looked into the matter at all, seems to be that automatic braking and shutting off of power is quite possible on electric trains which pass by signals set against them, and that this would also be possible for steam railroad equipment. The express traffic on the New York subway is controlled by this sort of automatic arrangement. The traffic on the Hudson Tunnels is also controlled in this manner.

The writer, for one, would like to see some agitation started to persuade or compel steam railroad companies to use some such device to properly safeguard the people patronizing these railroads.

Yours truly,

Wm. M. Torrance.

39 Cortlandt St., New York City, Nov. 21, 1910.

[We have commented on our correspondent's suggestion in our editorial columns.—Ed.]

The Reinforcement Steel of the High Bridge Dam.

Sir: In Eng. News of Nov. 24, 1910 (p. 564), there appeared a description by Mr. F. S. Tainter of a buttressed masonry dam that was built at High Bridge, N. J., for the Taylor Iron & Steel Co. A photograph was shown, as well as a plan and elevations. The peculiar feature of this dam was its construction, being made up of a curtain wall supported at intervals by buttresses. The masonry was of rubble, and each panel of the curtain wall was reinforced by horizontal I-beams joined by horizontal I-beams in the buttresses. There were also vertical I-beams where the buttresses joined the wall, but which do not have much importance. It is about the horizontal reinforcement that I wish to take issue with the author.

He said that in plan these I-beams formed a series of "horizontal arches" all parts of which were in compression. Remembering that the stress is from the

up-stream side, and against the flat "arch," this member has to sustain a load transverse to its length and is therefore not in compression but bending. The whole dam, in fact, is a continuous beam with horizontal instead of vertical loading, and supported by horizontal instead of vertical posts [buttresses]. The only compression is in these buttresses. If the dam is regarded as a reinforced-concrete structure, the metal is placed where it will do no good; for in the curtain wall it is in the neutral axis, and in the buttresses the I-beams are in compression, for which stress they are not needed. The only advantage in placing them at all, in my opinion, is to take up shear at different places, and to help tie the masonry together.

And now, having said so much in criticism, it is but fair to add that I have never seen a dam more handsome in appearance. The simplicity and harmony of its lines, the variety afforded by the buttresses, each part having a distinct purpose and living up to it, all give it a beauty that cannot be improved by any architectural embellishments, and make the structure one that other designers might well imitate.

Sincerely,

A. W. Bedell.

Chappaqua, N. Y., Dec. 12, 1910.

[Mr. Tainter's reply to the above comments follows.—Ed.]

Sir: In view of the very fair and courteous tone of the criticism of Mr. Bedell of my statement in your issue of Nov. 24, 1910, and of the fact that this criticism is addressed to my statement of the manner in which the steel skeleton of the High Bridge Dam is carrying its load and not to the safety of the structure, it would seem an unwarrantable intrusion on your space to enter into a full discussion of the mathematical question involved.

Mr. Bedell is entirely correct in his statement as to the value of the steel as a bond tying the masonry together, while also acting in the buttresses to take up shear. As Prof. Atcherley has pointed out, stresses of this nature may be very serious.

The exact distribution of stresses in dams, however, is not known. Whether rubble masonry of the dimensions used at High Bridge will not of itself act as an arch is a question on which an interesting but academical debate might be waged. In any arch the mathematical imperfections incident to all practical construction render the location of the resultants uncertain.

The I-beams at High Bridge are not on the tension side of the wall (regarded as a beam), and, therefore, can hardly be subject to tension, unless the wall be regarded as a mere watertight covering incapable of taking up strains. This is certainly an impossible assumption. The beams, therefore, are either entirely unloaded or in compression; if the latter, either there will be a dangerous tension on the masonry face, or an arch is formed for all practical purposes; if the former, the masonry itself must be acting as an arch, with the steel as an integral part thereof.

This question has been raised several times. All engineers who have taken it up have agreed in the opinion that if such a construction were acting as a reinforced beam, cracks would appear in the face. This has not been the case in either the Carnegie Dam, at Princeton, N. J., built by me six years ago, or the High Bridge dam, although both structures have been subjected to very severe floods. F. S. Tainter.

Hoboken, N. J., Dec. 17, 1910.

Train Movements at South Station, Boston.

Sir: In Engineering News, Dec. 8, p. 638, you show (Fig. 2) the number of trains arriving and departing each half hour from South Station, Boston, June 5, 1910. On the face of it, this diagram does not show what the title indicates, inasmuch as no trains of the Boston & Albany R. R., which use this station, are included in the diagram. Neither is there any direct statement in the report, with which this is published, to indicate to the general reader that the Boston & Albany trains are not included in this diagram; that is left to be inferred as the report relates to the New Haven and Boston & Maine roads only.

Alongside of this diagram is another (Fig. 1) showing the number of trains arriving and departing, each half hour, at North Station, Boston, June 20, 1910, which actually shows all trains arriving and departing from that station. A comparison of these two diagrams indicates that the North Station has a greater traffic than the South Station.

As the South Station has the greatest number of trains arriving and departing per day or per busy hour, of any steam railroad terminal station in the United States, it is unfortunate that this diagram was so published, that a wrong inference could be made. Thinking that you might like to publish a correct diagram as a matter of general interest, I enclose herewith a black and white print which shows the movement of all trains into and from this station.

If there was anything in this Boston report from which a reader could infer that only the trains of the N. Y., N. H. & H. R. R. in South Station are represented in Fig. 2 it might not be necessary to make such correction, but there does not appear to be any such explanation and there is no corresponding diagram to show the number of Boston & Albany trains in the South Station.

Very truly yours,

Geo. B. Francis, M. Am. Soc. C. E.
Consulting Engineer.

10 Bridge St., New York City, Dec. 12, 1910.

[The diagram which Mr. Francis criticises accompanied the report of Mr. E. H. McHenry, Vice-President of the New York, New Haven & Hartford R. R., on the substitution of electric traction for steam in the Boston metropolitan

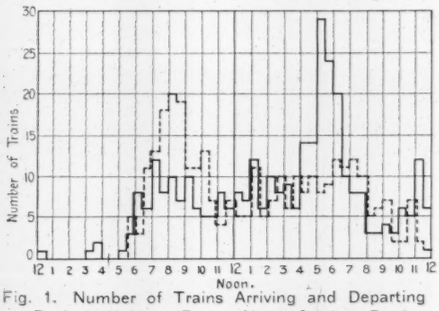


Fig. 1. Number of Trains Arriving and Departing Each Half Hour From North Station, Boston. (June 20, 1910.)

district. As the Boston and Albany traffic was discussed in a separate report, naturally no account of those trains was taken. The diagrams were primarily to illustrate the train movements that had to be provided for and not for comparison of traffic at various stations. To illustrate Mr. Francis criticism of the report we have reprinted Fig. 1 and accompanied it with his Fig. 2.—Ed.]

The Physical Meaning of Entropy Defended.

Sir: A consideration of the criticisms called forth by my article, "The Physical Meaning of Entropy," in Engineering News, Sept. 1, indicates that further proof seems to be required to justify the contention that the definition as given does point out the physical significance of this term.

It has been proved mathematically, that "entropy is the minimum unavoidable waste per degree of the absolute temperature at which all of this waste may be rejected." Is entropy, from this point of view, any more difficult to comprehend in a physical sense than specific heat, which is heat required to raise temperature per degree $\frac{Q}{T}$, than electrical capacity, which is the quantity of electricity stored per unit different of potential $\frac{q}{E}$; than velocity, which is distance passed over per unit of time $\frac{s}{t}$? Is not unavoidable waste a perfectly familiar physical entity? The white puffs of vapor emitted from the exhaust pipe of a steam engine remind us of its existence through the sense of sight; accidental contacts with the exhaust of a gas engine remind us of its existence through the sense of feeling. Do we not show our comprehension of unavoidable waste by the care we take in providing circulating water to abstract this waste from the exhaust of a condensing steam engine? If unavoidable waste is so commonly appreciated, wherein is the difficulty in understanding the physical significance of waste heat per degree of temperature?

If, in generating dry steam at 165 lbs. absolute from feed water at 32° F., the entropy is numerically equal to 0.5235 + 1.0370 or 1.5605, then the unavoidable waste per degree of temperature at rejection is 1.5605 B. T. U. If the temperature at rejection is 400°, absolute, the total unavoidable waste is 400 × 1.5605 or 624.2 B. T. U.; if the temperature at rejection is 600°, absolute, the total waste is 600 × 1.5605 or 936.3 B. T. U.; and so on.

The question seems to have been asked: wherein does my definition of entropy differ from other definitions previously advanced? The answer is: in the point of view.

To explain, let us consider two different but correct definitions of the area of a rectangle: (1) the product of length times width, which is purely mathematical and suggests the formula $l \times w$; (2) a plane surface bounded by four straight lines at right angles to each other, a physical definition which suggests a mental picture of a surface. When we wish to calculate the area of a rectangle, we think of the first definition; when we wish to include the area of a rectangle in some graphical construction, we think of the second definition.

The distinction between these two definitions of a rectangle is precisely the distinction between the two classes of definitions of entropy which have been advanced. Clausius gave the name "entropy" to the expression

$$\int_{o}^{Q} \frac{d\,Q}{T};$$

Swinburne has stated:

Increase of entropy is a quantity which, when multiplied by the lowest available temperature, gives the incurred waste.

Ripper's definition is:

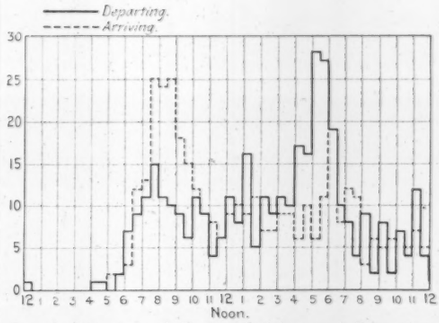


Fig. 2. Number of Trains Arriving and Departing Each Half Hour From South Station, Boston. (June 5, 1910.) (Corrected, from a similar diagram in Engineering News, Dec. 8, to include Boston & Albany R. R. Trains.)

Entropy is length on a diagram in which area represents a quantity of heat and the ordinates represent absolute temperature.

Prof. Kent's modification of my definition reads:

Entropy is the quotient found by dividing the minimum unavoidable waste by the degrees of the absolute temperature, etc.

All of these definitions are purely mathematical and give us no idea of what entropy represents in a physical sense. Indeed, the last named definition, though correct mathematically, is not practical since it assumes that unavoidable waste may be determined independently of the entropy—an assumption, to the writer's knowledge at least, which cannot be fulfilled by any known method.

The definition which I have advanced (entropy is the minimum unavoidable waste per degree of the absolute temperature at rejection) is a true physical definition of entropy. It points out the amount of waste which could be avoided theoretically by lowering the temperature at rejection one degree; or the additional waste incurred if this temperature is raised one degree. When we wish to calculate the numerical value of entropy, we use the expression

$$\int_{o}^{Q} \frac{d\,Q}{T};$$

when we wish to make use of it in actual problems, we think of it as the minimum unavoidable waste per degree of temperature. There is no conflict between these two definitions.

Although my definition of entropy has been developed by assuming that the working substance passes through a complete cycle of changes, it follows by no means that this definition is inapplicable when simple thermal changes are considered. In the original article it was proved that entropy is the minimum unavoidable waste per degree of temperature at rejection when a working substance is degraded from one state to another. In this case, entropy points out the relative amount of heat which must be wasted in degrading the state of the substance—this relative waste being independent of the path by which the substance attained its initial state and, likewise, independent of the path by which it attains its final state, provided that all waste is rejected at a constant temperature.

The entropy for the heat required to raise the temperature of air from 100° to 200° at atmospheric pressure, is the relative amount of this heat which must be wasted if we attempt to obtain work by degrading this air back to its initial state. Thus the conception of entropy as relative heat waste is applicable to all thermal changes from which work may be obtained.

A few comments on the expression "change of entropy" may be of interest. It has been shown that

$$L = T_o \int_{o}^{Q} \frac{d\,Q}{T}$$

where L is the total unavoidable waste, T_o is the absolute temperature at rejection, and

$$\int_o^Q \frac{d\,Q}{T}$$

the entropy. By the theory of limits this equation may be written

$$L = T_o \left[\int_o^{Q_1} \frac{d\,Q}{T} + \int_{Q_1}^{Q_2} \frac{d\,Q}{T} \right]$$

The expression

$$\int_o^{Q_1} \frac{d\,Q}{T}$$

represents the entropy of the heat Q_1, while the expression

$$\int_{Q_1}^{Q_2} \frac{d\,Q}{T}$$

represents the "increase of entropy" due to the heat $Q_2 - Q_1$. Thus, the increase of unavoidable waste per degree of temperature at rejection due to increasing the heat absorbed, is the "change of entropy."

Entropy is not only the "minimum unavoidable waste per degree of temperature at rejection," but it is the minimum unavoidable waste for each and every degree of this temperature within the limits of zero and plus infinity. This requires proof.

A consideration of the manner in which the equation

$$L = T_o \int_o^Q \frac{d\,Q}{T}$$

was obtained will disclose that the only limitations are —that T_o, Q, and T shall be positive and finite, and that T_o shall be constant. The integral sign takes care of any law connecting change of temperature with the absorption of heat.

Since T_o may be any temperature, we may write the above equation as follows:

$$L = (T_s \pm n) \int_o^Q \frac{d\,Q}{T} = T_s \int_o^Q \frac{d\,Q}{T} \pm \int_o^Q \frac{d\,Q}{T}$$

where T_s represents some standard temperature and n, the number of degrees of variation from this standard. Does not

$$\pm n \int_o^Q \frac{d\,Q}{T}$$

indicate the variation in unavoidable heat waste due to changing the temperature at rejection n degrees, and is not

$$\int_o^Q \frac{d\,Q}{T}$$

the variation of heat waste for each and every degree of this change? Is not the conclusion justified?

A moment's consideration of entropy from the point of view advanced will show that, indirectly, the entropy for a given quantity of heat is the potentiality of this heat to produce work. For, by lowering the temperature at rejection n degrees, do we not cut down the unavoidable waste, ϕ heat units per degree, where ϕ is the entropy. Do we not, therefore, increase the amount of heat convertible into work by ϕ heat units per degree? Is not this analogous to the potentiality of weight to produce work? By lowering the temperature at rejection from T_s to T_o, the work which becomes available is, $Wh = \phi\ (T_s - T_o)$. By dropping a weight from h_s to h_o the work which becomes available is $Wg = mg\ (h_s - h_o)$. The symbolical analogy between ϕ and mg immediately suggests Prof. Zeuner's "heat-weight" analogy for entropy; and if we replace mg by its more general expression

$$\int_o^{m_1} \int_o^{m_2} K \frac{d\,m_1\,d\,m_2}{d^2},$$

we are reminded of Prof. Reeve's definition which is — "that *Entropy* = ΣMM; a state of matter, the degree of subdivision of its mass."

But is the analogy between entropy and weight entirely logical? The work made available in each case is energy, which is expressible as force times distance. If entropy is of the nature of weight, or force, the dimensional equations would immediately show that temperature is of the order of length—a conclusion by no means conceded by physicists. The physical significance of Prof. Reeve's definition is not clear; for, although we know that the interaction of masses separated by distances produces force and work, we are not able to sense the significance of what is represented by the expression ΣMM.

Returning to the indirect conception of entropy as the potentiality of heat to produce work, we have no difficulty in paralleling it with the conception of mg as the potentiality of weight to produce work; for does not mg represent the work available when weight falls through unit distance? A reconciliation of the dimensional equations for different kinds of potential is still a problem for the physicist, for under the system of fundamental units now in use different kinds of potential involve different secondary fundamental units. Thus, electrical potential involves specific inductive capacity, magnetic potential involves permeability, and heat potential involves temperature.

To test our grasp of the physical meaning of entropy as — "unavoidable heat waste per degree of temperature at rejection" or, merely relative unavoidable heat waste, let us proceed to work out a problem of some interest to engineers at the present time. How much more power may be obtained theoretically by installing a low pressure turbine to operate in connection with a non-condensing steam engine? For the purpose of the problem, feed-water in both cases will be taken at 180° F. and the steam will be assumed dry at 160 lbs. absolute. The engine will exhaust at atmospheric pressure and the turbine at a pressure corresponding to a vacuum of 28 ins. of mercury.

By referring to steam tables we find that the total heat added is 335.1 + 857.7 — 148 or 1044.8 B. T. U.; that the entropy from water at 180° is 0.5204 + 1.0423 — 0.2633 or 1.2994; that the entropy from water at 100° is 0.5204 + 1.0423 — 0.1297 = 1.433; that the absolute temperature corresponding to atmospheric pressure is 212° + 459.5° or 671.5°; and that the absolute temperature corresponding to a vacuum of 28 ins. is 100° + 459.5° or 559.5°.

In calculating the work possible when exhausting into a vacuum of 28 ins., we do not need to consider the work necessary to restore the working substance (water and vapor) from hot-well temperature at 100° to water at 180° for it was assumed that feed-water is available from some source at a temperature of 180°. The entropy to determine the work possible in this case must therefore be computed from water at 100° F.

From the definition of entropy, the minimum waste per degree of temperature at rejection for the engine is 1.2994 B. T. U., and the total waste is, therefore, 1.2994 × 671.5 or 872.5 B. T. U. The minimum waste per degree of temperature at rejection for the combined engine and turbine is 1.433 B. T. U., and the total waste is 1.433 × 559.5 or 801.8 B. T. U.; but the waste involved in the problem under consideration is 801.8 — 80 or 721.8 B. T. U. since we do not have to heat the feed-water from 100° to 180°.

The total maximum work available from the engine is, therefore, 1044.8 — 872.5 or 172.3 B. T. U.; and the total maximum work available from the combined engine and turbine is 1044.8 — 721.8 or 323.0 B. T. U. The work obtainable from the turbine is therefore 323.0 — 172.3 or 150.7 B. T. U. per pound, and this represents an increase of power equal to $\frac{150.7}{172.3}$ or 87%. The simple and defensible conception of entropy as relative unavoidable waste, or, indirectly, as the potentiality of heat to produce work, will come as a surprise to many who have been accustomed to thinking of it as a mathematical fiction having no physical meaning, or as a property of matter which Earth's inhabitants are not able to sense. The validity of the conception herein defended is based on the principles of pure mathematics and involves neither approximations nor average conditions. The correctness of the conception has been checked by application to complex problems which may be solved in other ways. It appears, therefore, that the purpose of this article has been accomplished.

A. L. Menzin.

823 Sheldon Bldg., San Francisco, Cal., Nov. 25, 1910.

Sir: I have read Mr. Menzin's articles on entropy with considerable interest, for he is the first one I know of to satisfactorily explain what has always been considered a more or less complicated function of heat. Differential equations are poor material from which to form a mental picture and, while integrating in the dark may bring forth very definite results, yet one will have much greater confidence in his work, and will understand the process better if he recognizes the quantities with which he is dealing. To remove the ambiguity that Prof. Reeves criticized, I would suggest to Mr. Menzin the following definition:

Entropy

$$\int_o^{Q_1} \frac{d\,Q}{T}$$

is the temperature rate of least heat waste.

Sincerely,

A. W. Bedell.

Chappaqua, N. Y., Dec. 2, 1910.

Notes and Queries.

In the article descriptive of the movable dams on the New York State Barge Canal, in our issue Dec. 8, 1910, p. 611, it was stated that the chains used to lift the lower curtains are from 1⅝ ins. to 2 ins. in size. This last figure is a misprint. The largest chain in use on the bridge is of 1½-in. metal, this being about the limit in size capable of being handled in such work.

ERRATA.—In the address of Gen. Wm. H. Bixby, Chief of Engineers printed on pp. 714-716 of this issue the following paragraph should be added on p. 715 to the section in the middle column entitled "The Effect of Waterways in Reducing Railway Rates":

But it must be remembered that while a canal or an improved river remains idle it represents a large amount of locked up capital not being utilized to best advantage. Appropriate legislation might bring about the desired reduction in the railroad rates along the parallel route just as effectually, and with no greater loss to the railroad and without imposing the cost of the canal or the river improvement upon either the state or federal government. Under such circumstances the principal advantage of the canal or improved river is that its freight-controlling action is direct and automatic so long as not interfered with by legislation, that its continued existence is more certain and much less liable to change than that of a paragraph on the statute books, and that its existence is at the same time a constant encouragement to growing commerce and an excellent safeguard against temporary congestion of transportation routes. So long as the waterway is to remain unused, its construction or maintenance is a question more of legislation than of navigation or transportation.

The Re-Working of Scrap Material on the Illinois Central Ry.

Much of the damaged or waste material which ordinarily goes to the scrap heap at railway shops can be worked over and utilized either for its original purpose or for some new purpose. In this way it has a value much higher than its scrap value (taking all cost of working into account), and a material saving is effected compared with the cost of new material. A number of railways have introduced economies of this sort to a greater or less extent. At the December meeting of the Western Railway Club a paper was presented by Mr. T. S. Sheafe, Engineer of Tests of the Illinois Central Ry., dealing with the system instituted by this railway which is said to be making a net saving of $9,000 to $10,000 per month.

The original plant (1907) erected for utilizing scrap iron by re-rolling consists of a building 45 × 145 ft. with a two-high rolling mill (cost, $600), high-speed engine, oil furnace, alligator shears (home-made) and an old steam hammer. The total cost of such a mill complete is about $4,100. The working force consists of a roller, heater, catcher, straightener and four laborers. From January, 1908, to October, 1910, this plant re-rolled 1,892 tons, an average of 56 tons per month. Truss rods, center pins and heavy round iron are used for rounds; arch bars are used for flats. The smallest rounds are ¾-in., owing to the high cost of rolling iron to a smaller size. The length of the bars averages 7½ ft. for rounds and 6 ft. for flats.

The author states that the re-rolled iron is superior to merchant bar iron, due to the rolling. It is used principally for bolts, and the operators of bolt-heading and bolt-cutting machines prefer it to new metal. In this shop, also, good second-hand iron is straightened for use in the blacksmith shop. Bent ¾-in. iron is cut to length for brakeshoe keys (without straightening) and for drift bolts.

All journal bearings removed from cars and locomotives were formerly scrapped, but are now sorted carefully. Those which are suitable are relined and returned to service, saving over $3,000 per month. They are used the same as

new bearings, although it is said that there is some difference of opinion among car men as to the use of the relined bearings.

Air hose are spliced; the two halves of good hose which have been chafed or cut being put together by means of a special nipple and clamps. About 150 hose per month are repaired in this way, and the saving is 46 cts. per hose.

Bent brake-beams are straightened and reinforced, although the simple straightening of such brake-beams has been discontinued by railways generally (according to the author) owing to the loss of strength in the process. The reinforcement consists of a 2 × 2½-in. angle extending nearly to the brake head and attached with six rivets. A plate would prove probably as effective and at less cost. A new brake beam of this description (167 lbs.) costs $2.41, and has a scrap value of 75 cts. The cost of reinforcing is only 64 cts. (material, 45 cts.; labor, 19 cts.). From May, 1909, to November, 1910, the shop reinforced 10,233 brake beams. A shop 22 × 70 ft. was erected for this work, at a cost of $700 for the building and $400 for the oil furnace, straightening devices and other equipment.

The accumulations of paint skins in every paint shop and paint gang are valuable when worked over, and are used for making new paint. On an average 15 barrels of skins per month are boiled. The mixture is about 350 lbs. of paint skins to 15 lbs. of raw oil and 100 lbs. of pigment. This makes one barrel of paint, and the saving is said to be over $22 per barrel. Two small buildings of corrugated iron construction were erected for the boiling work ($250) and for a paint mill ($950), the latter being equipped with mixing and grinding machinery ($800). The force consists of a foreman, two paint mixers and four laborers. During October, 1910, there were made 6,450 gals. of paint (body color, freight car color and passenger car roof color). The net saving on this amounted to $1,300.

A car cleaning material is made in the laboratory, and this not only does its work well but insures the life of the varnish, as the material contains no acid. The actual saving is about $50 per month, but of greater importance than this is the prevention of the use of destructive car cleaning preparations on the passenger coaches.

Explosion in a Battery House in the Grand Central Station Terminal Yard, New York City.

The disastrous explosion of Dec. 19 at the battery house of Substation No. 1 of the New York Central & Hudson River R. R. Company's new Grand Central station terminal in New York City was briefly recorded in our last week's issue. We show herewith a series of photographs showing the wrecked buildings, which were taken shortly after the explosion occurred, and will give the reader some idea of its violence. The diagram plan Fig. 5 shows the destroyed portion of the battery house itself. The construction of this house is represented in Fig. 7, which has been sketched from the architects' plans.

As can be seen from Fig. 7, the lowest floor of the house is some 10 to 12 ft. above the street level, while the yard track level is about 22 ft. below the street. There was thus an open space some 30 ft. high under the building, closed on the front by the 50th St. wall of the house and the street retaining wall, but entirely open to the south and east. At half the height of this space there was an inclined driveway built of 12-in. I-beams carried by deep plate-girders, but lacking its concrete floor arches and floored instead with temporary wooden planking. This driveway divided the space under the house into two stories, each 15 to 20 ft. high, but both completely open to the south face and the upper story open also at the east end. The theory at present most generally accepted as the cause of the explosion is that Pintsch gas escaping from a broken pipe filled these open spaces under the building with a mixture of the gas and air; that this gas and air mixture was ignited in some manner and its explosion caused the destruction shown in our views.

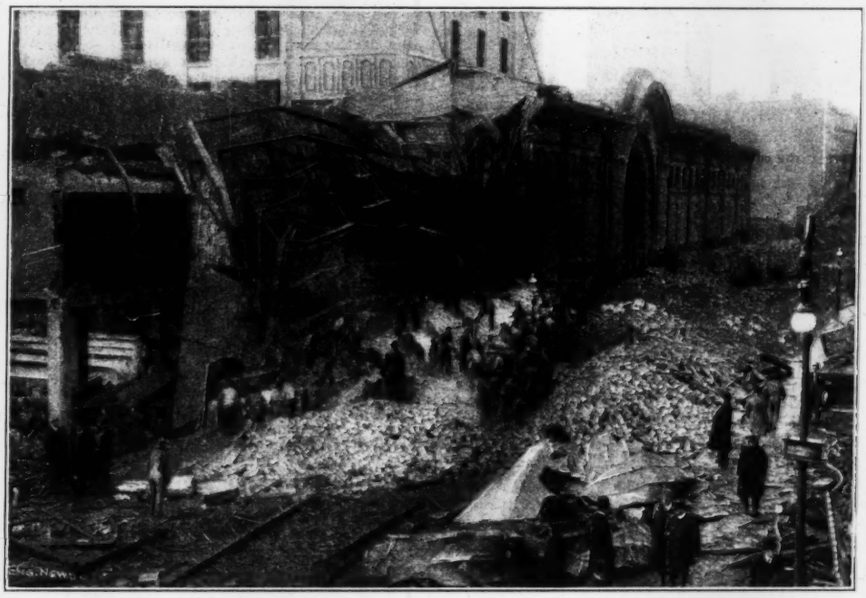


FIG. 1. LOOKING INTO 50TH ST. WEST FROM LEXINGTON AVE.
(Wrecked battery-house in foreground. Unfinished power-station at left in rear. Tops of cars in depressed yard visible at left.)

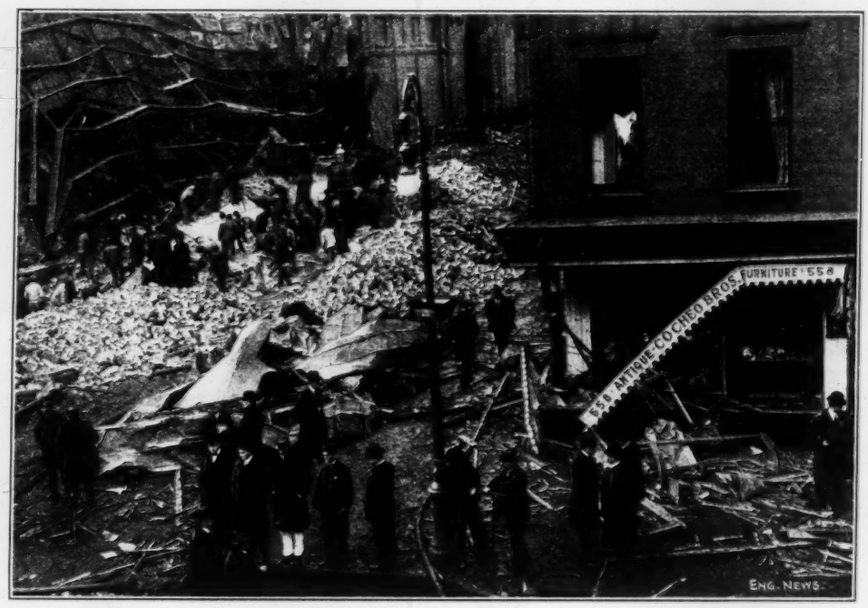


FIG. 2. ANOTHER VIEW WEST IN 50TH ST.

The damage done outside the wrecked building does not appear to be significant except in a few points. A two-story brick firehouse (Fig. 4) directly across Lexington Ave. from the wrecked battery house has the parapet of its west wall, three or four feet high, broken and overthrown on a good part of the length of the building. Lower down, this wall has marks of being struck by several wooden beams, one of which in fact remained sticking in the brickwork. A street-car passing between the battery house and the firehouse was blown over and badly smashed. North of the east end of the battery house, a tenement on the northwest corner has marks of damage on the cornice of the south wall, and one of the top story windows lacks a triangle of brickwork over the opening. The store-front on the ground floor of this house was wrecked (Fig. 2). Practically all the damage beyond this consisted breaking windows, shaking down plaster ceilings, and in a few cases forcing in window door frames by pressure or shaking down arches of door openings. One building was found cracked, several blocks away from the battery house. The area within which windows were broken extends much farther south than north, which may be significant in view of the fact that the space under the building in which the gas is supposed to have collected and exploded is open toward the south. The cars in the railway yard just south of the battery house were not damaged extensively; but their ends and not their sides were toward the explosive wave.

The known events preceding the explosion were, about as noted in our last issue: A train of multiple-unit (electric) cars in the terminal yard was being run north on a track about in line with the second row of columns from the east end of the battery house. The motorman failed to stop the train in time, and it collided with and broke through the bumping post just south of the battery house. In Fig. 3 the second car is the head of the train in question. Just behind the southerly row of columns a set of three (or four) pipes carrying steam, Pintsch car-lighting gas and compressed air extended

from east to west under the battery house, passing through openings cored in the concrete fender walls, as indicated in the drawing Fig. 7. The collision resulted in breaking the gas pipe, and as the gas was not shut-off at the storage station two blocks south until about half an hour afterward, a large amount of gas escaped, some 14,000 cu. ft., it is claimed. Shortly after the gas was cut off the explosion occurred.

The even distribution of the damage over the whole of the building affected is characteristic of a gas explosion. Where a charge of dynamite is set off, the destructive effect is greatest in the immediate neighborhood of the explosive and rapidly diminishes away from this center.

Some incredulity has been expressed in the public prints as to a gas explosion being of sufficient force to do such extensive damage. It is little realized, apparently, what enormous potential energy is contained in even a moderate volume of combustible gas if mixed in proper proportions with air and exploded. A brief computation may be of interest, therefore.

Suppose we take a volume of 100 cu. ft.* of gas of 600 B. T. U. per cu. ft. calorific power. When mixed with air in the proportions for most violent explosion the mixture could be contained in a small room about 12 ft. cube. The total heat units in this gas would be 60,000 B. T. U. and the total foot-pounds of potential energy would be 60,000 x 772 = 46,320,000 ft.-lbs. If this gas were exploded in small quantities behind a piston in a gas engine cylinder, something like 15 to 25% of this could actually be obtained as mechanical energy; and given proper mixture, something like this energy will actually be generated when the gas is exploded in a confined or partially confined space and will be exerted against any obstacle. This means that only 100 cu. ft. of gas exploding when mixed with air may have a potential destructive power of over 10,000,000 ft.-lbs.; or it could lift a structure weighing a thousand tons to a height of 5 ft.

Of course under actual conditions in accidental gas explosions, the mixture of gas and air is imperfect, too rich in some places for greatest explosive efficiency and not rich enough in others. It will be apparent, however, from the above computation, that even a very few cubic feet of combustible gas mixed with air and fired has potential energy sufficient to cause an explosion of most destructive effect.

Waterways: Their Limitations and Possibilities.†

By FREDERIC A. DELANO,‡ M. Am. Soc. C. E.

I do not believe that the development of waterways, solely in the interest of the general public, would hurt the railways. Even if I thought otherwise, I hope that I should have enough public spirit to advocate that which I believe to be for the general good. Whatever is for the public good ought to be done even if in consequence some special interest suffers. The question that ought to be considered by all is whether development of waterways is the best way to secure cheaper and more adequate facilities for transportation. When I say "cheaper," I have in mind the entire economic cost of transportation, including not only the rates that the shipper pays to the owners of the boats, but also what the public pays in taxes for the improvements and construction of the waterways.

When we consider the cost of railway transportation, we do not consider merely the cost of moving the engines and the cars. We consider also the cost of providing and maintaining the roadway, the stations and other structures. Obviously, all costs incidental to the soliciting of freight, insuring it in transit, interest on capital invested, and charges for replacements and betterments are applicable to waterways as well as to railways; and we must not deceive ourselves by reason of the fact that some of these expenses are borne by the general government, instead of by the traffic moved.

The increasing capacity and draft of sea-going vessels which necessitates the dredging of harbors to great depths, has a most important bearing on the question of the development of inland waterways. It is sometimes contended that we should dredge our rivers and dig our canals so wide and deep that vessels can carry goods directly and without trans-shipment between cities situated on them and all the ports of the world. Some of the people of Chicago have visions of ocean vessels loading in their harbor, steaming down through the drainage canal, the Illinois River and the Mississippi River, and thence to Europe; also through the Panama Canal to the Orient; or by the Great Lakes and St. Lawrence canals, to Europe.

Such thoughts are idle dreams, and the trend of economic conditions in ocean transportation makes any such suggestions increasingly impossible. It might, for example, have been considered with the class of vessels

*The quantity of gas which escaped from the broken pipe at the Grand Central yard is said to have been at least 14,000 cu. ft.

†Extracts from a paper read before the National Rivers and Harbors Congress at Washington, D. C., Dec. 8.

‡President, Wabash Ry., Chicago.

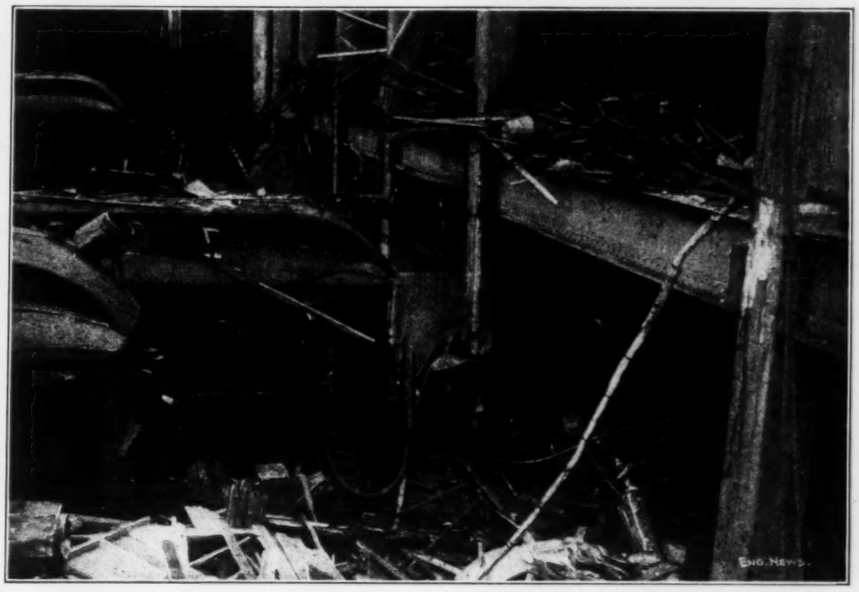


FIG. 3. AT REAR OF BATTERY HOUSE, LOOKING DOWN AT CAR WHICH BROKE THROUGH BUMPING POST.

FIG. 4. LEXINGTON AVE., LOOKING NORTHEAST, SHOWING CAR DAMAGED BY EXPLOSION.

(This car was overturned, falling on an automobile. Several passengers in the car were killed. The firehouse on the southeast corner of 50th St. and Lexington Ave. has part of the coping and parapet of side wall broken off.)

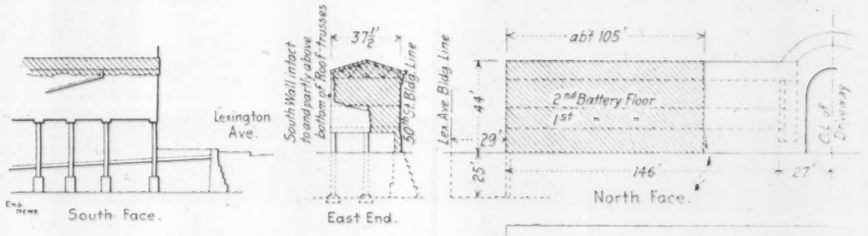


FIG. 5. DIAGRAM OF BATTERY HOUSE SHOWING EXTENT OF DESTRUCTION.

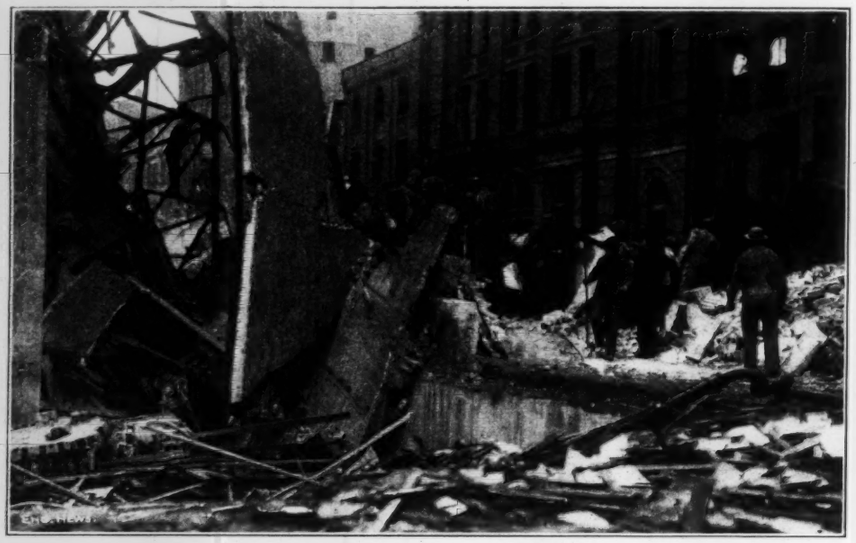


FIG. 6. VIEW AT EAST END OF BATTERY HOUSE.

which were used on the ocean twenty-five or more years ago. It cannot be considered with the class of vessels which are economical and necessary to-day, for, regardless of the relative depths of waterways, vessels which must withstand the buffetings of the waves and storms of the ocean must be built much more strongly and, therefore, at much greater cost than vessels for inland carriage. The average cost of an ocean steamship per ton of capacity is $71; of a steamship on the Great Lakes, $41.50; and of river tow boats and barges capable of carrying 10,000 tons of freight on an 8½-ft. draft, only $12.*

A lake or ocean vessel is poorly constructed for navigating a canal or tortuous river, even with a moderate current; its ratio of length to beam is too great and it cannot be maneuvered at slow speed. Furthermore, a vessel costing $71 per ton of capacity cannot be operated economically where it must, perforce, be navigated slowly.

A great many intelligent persons concede that the traffic on the inland waterways of the United States (except the Great Lakes) has declined, while that on the waterways of Europe has increased, because of the cheap and superior service of our railways. They contend that we can make our waterways successful competitors of our railways only by making our waterways greatly superior to the waterways of Europe. Therefore, they advocate digging canals and canalizing our rivers to depths exceeding those attained on such waterways in any other country. One of the plans is for a 14-ft. waterway from Chicago to New Orleans.

It is questionable if the results would be worth the cost. The aim of public policy should be to cause the provision of such facilities of transportation as will be able to handle our commerce at the least economic cost; and in economic cost I include the taxes the public would have to pay in order to provide and maintain deep waterways.

The report of the British Royal Commission shows that the expenditures of France on its rivers up to 1905 averaged $30,000 a mile, and on its canals, $102,675 per mile. The average density of traffic on French waterways in 1905 (that is, the number of tons handled one mile per mile of waterway per year) was 420,000 tons. Germany had spent on its waterways an average of $30,300 per mile, and on its canals, an average of $42,250, and the average density of traffic on them was 1,500,000 ton-miles. The canalization of the Main cost $95,000 per mile. The construction of the Teltow canal cost $290,000 per mile.

The interest and maintenance charges paid by the government of France on its waterways amounted to 4.2 mills per ton-mile of traffic handled, which added to the average rates which the shippers paid to the boats, makes the economic cost of water transportation 10 mills. The interest and maintenance charges paid by the government of Germany amount to about 0.84-mill per ton-mile, which, added to the average rate of 5 mills, makes the total economic cost of water transportation almost 6 mills.

The greatest density of traffic on any river in Europe is on the Rhine, where it amounts to 11,400,000 ton-miles per mile per annum. The density on the Elbe is 5,800,000 ton-miles. To get the depths advocated in this country would require very much greater public expenditures than those that have been made in Europe.

The average capitalization of the railways of the United States is $59,259 per mile of line, and this, of course, includes equipment and terminals, as well as roadway. The number of tons carried one mile per mile of line by our railways in 1909 was 953,986. The density of traffic of some of our large railways rivals that of the greatest waterways of Europe. The number of tons hauled one mile per mile of line per annum by the Delaware, Lackawanna & Western in 1908 was 3,886,814; by the Philadelphia & Reading, 4,164,131; by the Pennsylvania, 4,723,834; and by the Bessemer & Lake Erie, 5,564,712, or over 13 times as much as the average density of traffic per mile on the waterways of France, and almost four times as much as on the waterways of Germany. A density of 3,000,000 tons of freight per mile of road on single track lines is not at all uncommon in the United States, and this movement is in addition to a very considerable passenger traffic.

These figures indicate to my mind that if, in order to provide inland water transportation which will be able to compete effectively against the railways, it is necessary to dig canals and to canalize rivers to depths of 14 or 20 ft. or more, we might better forego having effective water transportation facilities and use our money to provide facilities for transportation by rail.

To dig a waterway 14 ft. deep would be to provide one that would not be any more useful than the Mississippi River already is for most of its length and than numerous other streams are. For over 95% of the vessel tonnage on the Great Lakes draws over 14 ft. of water, and over 80% of this draws over 18 ft. It is evident, therefore, that lake vessels could not be used on a 14-ft. waterway, and, of course, ocean steamships could not be used where lake steamships could not be. Even if the Lakes-to-the-Gulf waterway were made sufficiently deep for lake vessels, and it were economical for them to use it, all water transportation on tributary streams would have to be carried in shallower draft vessels, requiring transfer.

Would it not be better to serve the entire Mississippi River basin with tow boats and barges which, like the much abused freight car, could go anywhere within the sphere of navigability, say 5,000 to 8,000 miles? Is not the real problem to find an economical vehicle of transportation adaptable in a large river system like the Mississippi River and its tributaries; a vehicle which shall do for that river system what the freight car does on our system of railways?

The stern reality is that even if a 14 or a 21-ft. waterway were dug, it would never be used by deep draft boats. A large vessel cannot be navigated profitably on a narrow channel, because the interest on its high cost makes it uneconomical. Col. Symons estimated that it would cost 38% more to carry grain with a lake freighter on a ship canal than it would with a tow boat and barges, and it was in consequence of his investigations and conclusions that the State of New York decided to deepen the Erie canal to 12 ft., instead of making a ship canal of it. Col. Symons' estimate did not allow for the greater cost of building and maintaining ship canals, but referred only to the expense that would be incurred by the owners of the boats. The operation of a deep draft vessel in a river channel having any considerable currents might be even more expensive than on a ship canal.

Furthermore, I assume that no one would advocate making not only the Mississippi, but all of its navigable tributaries, 14 or 20 ft. deep. Then even if it proved practicable to navigate deep draft vessels on the Mississippi, they could not be navigated on the tributary streams. Then one of two things would happen: either the vessels in which goods were loaded on the smaller streams would be sent through to destination with the goods (in which case the deep draft vessels would not have them to haul); or the goods would have to be transferred to the deep draft vessels, and transferring goods from boat to boat is as expensive as, and often even more expensive than transferring them from car to car. To develop a waterway system in this way would be like building the main line of a railway with a broad gage and the branches with a narrow gage.

So far as I can learn, it is the opinion of practically all of the United States army engineers who have investigated the subject, that a tow boat with 6 to 9 ft. draft, towing barges with a combined capacity of 8,000 or 10,000 tons, would be able to handle traffic cheaper on the Mississippi River, even if it were deepened 14 ft. or 21 ft., than could a lake vessel with a deep draft. And the tow boat and barges would be able to navigate many of the shallow tributaries as well as the Mississippi, which would avoid the cost of transferring freight originating on the branch rivers. Needless to say, the cost of dredging the Mississippi River and its tributaries to a minimum depth of 6 ft. or even 9 ft., and maintaining that depth, would be very much less than the cost of digging it to a uniform depth of 14 ft.

Boats having a draft of 25 to 30 ft. can now be taken from the Gulf of Mexico 270 miles to New Orleans; boats of a draft of 9 ft., 840 miles further, to Cairo, Ill.; and

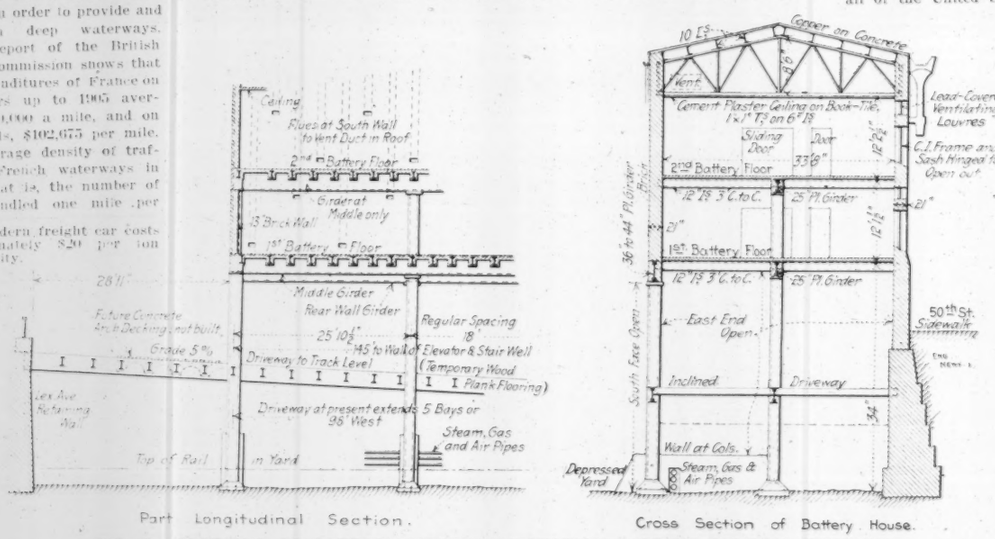


FIG. 7. SECTIONS OF BATTERY HOUSE, SUBSTATION 1, GRAND CENTRAL TERMINAL.
(S. W. Cor. 50th St. and Lexington Ave., New York City.)

boats of 8 ft. draft for another 182 miles from Cairo to St. Louis. It is stated by the board of army engineers that the Mississippi and the Illinois rivers and the Illinois state canal from St. Louis to Chicago, are now able to accommodate vessels having a draft of 4½ ft.

It would seem, therefore, that all that reasonably could be asked, or ought to be asked, of the general government, so far as our navigable rivers are concerned, is that it shall dredge them to depths sufficient to accommodate tow-boats and barges such as can now be operated on the greater part of the Mississippi River drainage system. To do more than this would involve an expenditure which would not be justifiable—which, in other words, would not make the total cost of water transportation less than it is by rail, whether it made it cheaper for the shipper or not.

If the government provided such channels as I have indicated; if the municipalities or private corporations provided modern and adequate water terminals; and if the water lines made rates, gave service, and formed soliciting staffs adapted to competing effectively with the railways, the water lines on our rivers would be as well situated to compete with railways as are those on any waterways in the world, except, of course, the oceans and the Great Lakes. And unless good water terminals were provided and the steamboat companies formed soliciting staffs, issued bankable and negotiable bills of lading and in other ways gave service which was as good in proportion to the rates charged as that of the railways, they would be as unsuccessful in competing for business (even if the government dug the rivers 20 ft. deep) as are the independent boat lines on the Great Lakes now in competing with the railways or with the steamship lines owned by the railways and large industrial corporations.

I do not say that if all these things were done, river steamships would be able to compete successfully against the railways. I feel very sure that if the water lines were subjected to the same kind of regulation as the railways, they would continue for an indefinite time to be unable to compete with the rail lines.

I merely say that under any circumstances these are conditions that must be met if our inland waterways other than the Great Lakes are ever to compete successfully against the railways. Whether, when the results that would be obtained are so entirely problematical, it is worth while to go on and spend millions in dredging the rivers and equipping water terminals, is for the public to decide.

The reason that the public have been misled as to the comparative cost of rail transportation and water transportation is that in the case of rail transportation the shipper pays the entire cost, including terminal service, and on top of this cost, a profit to the transportation company. In the case of water transportation, the shipper pays only the bare cost of carriage, and no interest on the money invested in the waterways, in the harbors and terminal improvements, nor in the maintenance and unkeep of the waterways.

Furthermore, the interruption of water transportation in our Northern waters is more than a serious inconvenience. It puts the burden of heavy interest charges for the entire year upon the traffic which can be handled only in the summer months.

A fact often overlooked in considering the cost of transportation as a whole, between producer and consumer, is the cost of assembling freight at the initial point or distributing it at terminal points. In this respect, while the railways have a great advantage, yet even with the railways, the cost of assembling farm products in many of our states (as pointed out in a recent report of the Department of Commerce and Labor) is greater than the freight paid by the farmer from his initial station to the point at which he markets his produce. In other words, a farmer who has to haul his produce eight miles to a railway station, at a cost of say 20 cts. per ton-mile, is spending as much as he would pay the railway for 210 miles of transportation at the average rates prevailing over the whole country.

It is fair to expect that good roads and automobile trucks will contribute much in the future towards cheapening the cost of assembling and distributing freight; and that there is much to be gained by intelligent public expenditures in the direction of improving the public highways and so reducing the cost of haulage to and from shipping points, whether these shipping points be stations of railways or of waterways.

Up to 1907, the Government had spent over $208,000,000 on the improvement of the Mississippi Valley waterway system alone. Between 1880 and 1906, canals and canalized rivers having a length of 2,841 miles, which has cost $73,168,000 were abandoned. Up to that time our total expenditures on canals and canalized rivers had been $283,208,863. The total Congressional appropriations for the survey, improvement and maintenance of harbors and waterways had been $552,943,525, and many millions of dollars have also been spent by the various States. We all know that a large part of these expenditures has been unwise, and certainly before expenditures are entered on which would be very much greater than any made in the past, the projects on which it is proposed to make them should be studied to much better purpose than like projects have been in the past.

AN EXPLOSION IN THE COAL BUNKERS of the U. S. Battleship "Michigan" was reported Dec. 21. One man was fatally burned. A similar accident on the U. S. Battleship "North Dakota" was noted in our last week's issue.

A COAL MINE EXPLOSION IN ENGLAND, Dec. 21, in the Little Hulton colliery of the Hulton Colliery Co., near the City of Bolton, killed 300 miners. Rescue parties were kept from entering the mine by the fire which followed the explosion. The hoisting machinery was completely disabled.

THREE SERIOUS RAILWAY ACCIDENTS were reported Dec. 24. The Scotch express collided with a light engine near Hawes Junction, England. Fire broke out in the wreckage and consumed the whole train with the exception of the locomotive and a baggage car. Eight passengers were killed and about 25 others injured. Reports state that the railway company has accepted full responsibility for the accident, which is ascribed to the forgetfulness of a signalman.

A butting collision on the Pennsylvania R. R. at Nevada, Ohio, killed four trainmen and two passengers. Westbound passenger train No. 15 was struck by an eastbound express train, the engineer of which, according to reports, had disregarded the block signals. A student engineer was in the cab with the engineer of the express.

A passenger train on the Norfolk & Western Ry. was derailed in a tunnel near Williamson, W. Va. Four mail clerks were killed in this wreck.

A FIRE IN PHILADELPHIA, Dec. 21, which destroyed the five-story brick building of the Friedlander Leather Remnants Co., at Bodine St. and Girard Ave., caused the death of 14 men, of whom 13 were firemen, and the injury of more than 30 others. Many of the firemen were in the building when the roof and three of the walls fell in. The fourth wall fell later and buried some of those engaged in rescue work in the ruins.

A FIRE IN CINCINNATI, OHIO, Dec. 21, destroyed one block of buildings in the factory district around Ninth and Sycamore Sts. Eleven large factory buildings were burned. The property loss, estimated at nearly $2,500,000, is reported to be the largest in the history of the city. Two firemen lost their lives under a falling wall, and a spectator was killed by a falling telegraph pole.

A SERIOUS FIRE IN CHICAGO in the Morris Co.'s buildings at the Union Stock Yards, on Dec. 22, caused the deaths of nearly 30 firemen, including the Fire Marshal (James Horan) and other officers of the department. The fire was in a six-story brick building used for beef storage, and having practically no windows and no means of access but the main doorways opening upon a covered loading platform between the building and the railway tracks. A large number of men were on this platform when an explosion forced out the wall of the entire upper part of the building. The explosion was only strong enough apparently to dislodge the wall, as it seems to have dropped almost vertically upon the platform, burying the men under a mass of wreckage. The bodies were recovered some hours later. The property loss has been estimated at $1,000,000.

A CHILD WELFARE EXHIBIT is to be held in New York City on Jan. 18, 1911, at the Seventy-first Regiment Armory. The general scope of the exhibit is in part indicated by the names of some of the sub-committees of the New York Child Welfare Committee (Fifth Ave. and 23d St.), under whose auspices the exhibit is to be held. Among the committees are those on Health, Streets, Recreation and Amusements, Libraries and Museums, and Work and Wages.

THE LARGEST STEAMSHIP IN THE WORLD, the "Europa" of the Hamburg-American Line, has just had its keel laid at Stettin. This monster vessel is to be 900 ft. long, 96 ft. in beam, with a tonnage of 50,000. Comparison with the "Mauretania," the largest vessel now afloat and the "Olympic" and "Titanic", twin ships, now under construction, is as follows:

	Length ft.	Tonnage
Mauretania	790	32,500
Olympic	860	48,000
Europa	900	50,000

BIDS FOR MANY MILES OF ROAD IMPROVEMENT in New York State are invited, on Jan. 9, 11 and 13, by the State Commissioner of Highways, Albany, N. Y. The roads are located in various parts of the state.

THE ELECTRIC TRACTION ZONE of the New York, New Haven & Hartford R. R. will be extended from Stamford to New Haven, it is announced. A power plant will be built at New Haven and the present station equipment will be increased to handle all traffic through the zone by electricity. Up to the present, freight has been only experimentally hauled. No date has been set for the beginning or completion of the work.

A HEIGHT RECORD of 11,474 ft. is reported to have been made by Archibald Hoxsey on Dec. 26 at Los Angeles, Cal., with a Wright biplane flyer. What is claimed as a world record for length of flight with a passenger was made by Lieut. Camerman, near Paris, on Dec. 21, 355 miles being covered in 5 hrs. 30 mins., without alighting. A Bleriot monoplane was used.

An amateur aviator, Cecil S. Grace, on Dec. 22, attempted to made a trip by aeroplane from Dover to Calais and return. The first half was safely made but on the return the machine disappeared in the fog and no trace had been found up to Dec. 28. It is supposed that the course was lost and that the machine fell in the North Sea.

THE NUMBER OF WOODEN POLES PURCHASED in 1909 by telephone and telegraph companies, steam and electric railroads, electric light and power companies in the United States has been reported by the Census Bureau. The figure is 3,739,000 compared with 3,249,000 in 1908 and 3,283,000 in 1907. These users in the year 1909 purchased also 3,509,000 cross arms, 6,168,000 brackets and 18,463,000 insulator pins. Of the 1909 figures, the telephone companies were reported as purchasers of 78% of the poles. This is 14% more than these companies purchased in 1908 and 26% more than they purchased in 1907. The steam railroads purchased 29% more poles in 1909 than in 1908, but 34% less than in 1907. The purchases by electric railroads and electric light and power companies were 18% greater than for 1908, though 7% less than for 1907. The average cost of poles of all lengths and woods in 1909 was $1.80, compared with $1.82 for 1908. Cedar poles formed 65% of the 1909 total figures compared with 68% for 1908 and 64% for 1907. Chestnut formed 16% of the total for 1909, 16% for 1908 and 19% for the total of 1907. The number of oak poles reported was 300% of the figure of 1907. Nearly a sixth of the total purchases of poles in 1909 were given some preservative treatment compared with a tenth of the 1908 purchases and an eighth in 1907.

A LAW-SUIT TO SECURE PAYMENT FOR WATER taken through bypasses, brought by the City of New York years ago against the American Sugar Refining Co., of New York, has at last been decided by a referee of the New York Supreme Court for the County of New York in favor of the city. The water taking took place at refineries in Brooklyn. The suit was based on a charge entered upon the books of the Water Department on Oct. 1, 1903, for unmetered water used during the six years ending July 30, 1903. The payment demanded was $525,600. The sum not having been paid, the city, on March 11, 1908, threatened to shut off the water unless the payment was made within 15 days. The company then brought suit to have the charge canceled and to secure an injunction against shutting off the water. Just what sum the city will collect under the decision (rendered Nov. 17, 1910, by Morgan J. O'Brien as referee), we cannot state. The referee says:

I have now discussed the essential features of the testimony and conclude that the defendant has sustained the burden resting upon it of establishing not merely an unauthorized (and so unlawful) use of water, but a fraudulent taking of water. Upon the evidence introduced before me, I am not convinced, however, that the defendant has satisfactorily established the amount of water so taken.

Later on, Mr. O'Brien stated:

I am satisfied, however, that the amount was much less than the defendant's estimate, viz., 1,800,000 gals. per day. In my opinion, 600,000 gals. per day was much closer to the truth than the defendant's estimate. But I have no power to make the dismissal of the complaint conditional upon the reduction of the defendant's demand. It is fully established that the plaintiff did take water both unlawfully and fraudulently, and that is determinative of this case.

The plaintiff is here asking the interposition of a court of equity to prevent the city from enforcing payment of its demand by cutting off its water supply. It is well settled that one who comes into a court of equity to ask relief must do so with clean hands, or otherwise he will be denied relief. As it has been shown that the plaintiff does not meet that condition, it cannot be given relief merely because the amount demanded is in excess of that properly due. It is doubtless true that the amount due to the city cannot now be determined with exactness, and therefore to hold the city to strict proof of the amount of water taken by the plaintiff would be to make the defendant suffer for the plaintiff's fraud rather than the plaintiff. That in such a case the defrauded party is not to be held to strict proof was decided in Krumenaker vs. Dougherty, 74 App. Div., 452.

The plaintiff made many objections to the evidence which was introduced on behalf of the defendant, but upon a review of the whole record, I am satisfied that the fraud of the plaintiff was fully established by competent proof. I do not consider it necessary, therefore, to refer to any of plaintiff's objections.

It appears that use was made of the pitometer in connection with the evidence submitted in this case. It should be added that in the conduct of the suit the Legal Department of the city was represented by Mr. Edward Maxson (2 Rector St.), Special Counsel for New York City.

PERMITS FOR CONSTRUCTING PORTIONS of the proposed new water-supply for San Francisco, Cal., have been granted to the city by Mr. R. A. Ballinger, Secretary of the Interior. The permits cover the Lake Eleanor Dam, and those portions of the Cherry Creek Conversion Canal and the Eleanor Creek Main Canal lying within the Yosemite National Park. The Department of the Interior has accepted $13,129 "as payment in full for timber and forest growth in the reservoir space of Lake Eleanor," and the permit authorizes the city to clear the lands which will be flooded by building the dam. This dam and reservoir grant is in accordance with a previous permit from the Department of the Interior granted May 11, 1908.

A TOLL ROAD IN MARYLAND, known as the Frederick Turnpike, is to be bought by the State through the agency of the Maryland Roads Commission. It is reported that the road is 66 miles long and that the selling price is $100,000.

TREATING WATER WITH CARBONATE OF LIME TO PREVENT LEAD POISONING.—For some twenty years past the moorland water-supply of Sheffield, England, has been treated with carbonate of lime to prevent lead poisoning. The following description of the process is from a paper on "The Sheffield Water-Supply," by L. S. M. Marsh, M. Inst. C. E. (Proc. Inst. C. E., Vol. CLXXXI., 1909-10, Part III., p. 10):

A measured quantity of levigated chalk—known commercially as Paris white—is placed twice a day in a small tank, oblong in plan and triangular in elevation, which is filled with water [line cuts in original]. A small revolving fan keeps the milky mixture continuously stirred, while a series of dredger-buckets, on a chain revolving through the liquid, empties it in small uniform quantities into a tank, where it is kept in motion by rotating plates. It is further diluted by a constant stream of water and discharged through a pipe below the gage-basin into the main supply. The whole of the machinery is worked by a small, triple-ram water-motor, the water from which is discharged into the gage-basin. The weight of chalk is so regulated as to cause the addition of a definite quantity ranging from about 1 to 2 grains per [Imp.] gal., according to the state of the water and its capacity for dissolving the carbonate of lime. The author believes this to have been the first apparatus of its kind designed for the prevention of the action of moorland water upon lead. The process is applied to the whole supply and has been adopted in other towns. The cost is about 0.03d. per 1,000 [Imp.] gals., and no complaints of plumbisolvent action have been received since its adoption.

SOME ESTHETIC CHARACTERISTICS OF GREAT CITIES.—A great city has continuity in its character, and a oneness in its many phases of expression. It is here that it exemplifies the strength of its organization. It is in its tone and color that it is most clearly shown.

The city which is white has the greatest refinement and charm. Paris, of modern cities the most beautiful in the world, is a city of ivory studded with pearly grey in a setting of green. Regent Street, London, is painted in white and cream, and to this is entirely due its attractiveness to the fashionable throng. The city which is white, and which scintillates and reflects the light of the sun, is the only fit background for the brilliant crowd with which every progressive city from Athens to New York has stood possessed.

Cities which are grey, like Edinburg, suggest rather endurance, grandeur, and romance. Grey cities are very fitting to these humid and northern climes.

All great cities are either white or grey. That which is a golden red harmonizing with the rich green verdure of the surrounding land, will ever suggest ease of existence, simplicity, and primitive life. Such a harmony can never suggest solidity of existence, as does grey, nor vivacity, as does white or cream.

We who are compelled to live in smoky towns of dull brick and blackened stone can but ill picture the cities of the East. The brilliancy of the cities of China, Hindostan, Egypt, North Africa, Asia Minor and Greece, seen in the zenith of their existence, with their gorgeous pennants, star-filled cornices, gilded domes and ivory facades, decorated in peacock hues, is quite beyond any conception of ours. Venice is their nearest approach. Such color has no place in the northern climes, but our colder and more humid cities, were it not for our smoke, could have a harmony entirely their own.

The character of a city is most evident when seen through the medium of its color, but it is also seen through its texture and form. The buildings and the outline of the streets, to be a fit complement to modern city life, should be regarded in the first place as a background and as a foil. In their form and outline they should be simple and strongly composed. Their surface should be hard and their enrichments delicate to a degree. Such is the street architecture of Paris.

The characteristics of a city expressed in its color, its texture, and its form, reflect on the citizen himself. Its design, the grouping of its buildings, and its outward expression are matters of vital importance to his well being; and that these should have been left to blind chance to develop in the past shows a lack of appreciation among those responsible for city building difficult to comprehend.—S. D. Adshead, in "The Town Planning Review," London, England

SEWAGE DISPOSAL BY DILUTION.—Of the 16 largest cities in the world, having a population of over one million inhabitants, every one without exception now employs the dilution method, where flowing water is available and a sufficient quantity of oxygen is dissolved in it, to represent a flow of fresh water equivalent to at least 3 cu. ft. per sec. for every thousand persons discharging sewage. The only cases where such a flow is not available are London, Paris and Berlin, because their rivers are too small. But even those rivers receive enough decomposing organic matter to keep the dissolved oxygen at the lowest practicable figure.—From a paper by Rudolph Hering, read before the American Institute of Chemical Engineers, Dec. 9, 1910.

Personals.

Mr. A. F. Blaess, Roadmaster of the Illinois Central R. R. at Louisville, Ky., has been appointed Assistant Engineer of Maintenance-of-way, with offices at Chicago, Ill.

Mr. Walter Loring Webb, M. Am. Soc. C. E., and Mr. James M. Kennedy have joined the engineering staff of Dodge, Day & Zimmermann, of Philadelphia, Pa., consulting and industrial engineers.

Mr. J. L. Ludlow, M. Am. Soc. C. E., consulting engineer of Winston-Salem, N. C., has been elected President of the Board of Trade of that city. Mr. Ludlow is also a member of the State Board of Health.

Mr. W. A. Parker, Chief Engineer of St. Joseph & Grand Island Ry., has been made Acting General Manager, succeeding Mr. James Berlingett, whose appointment as Assistant General Manager of the Virginian Ry. was noted in these columns on Dec. 8.

Mr. Louis C. Kelsey, M. Am. Soc. C. E., of Salt Lake City, Utah, and formerly City Engineer of that city, has opened an office in Portland, Ore., for the practice of engineering, dealing especially with problems of water supply, water power and municipal work. Mr. Kelsey is at present engaged in the design of water-works and sewerage systems for the city of Gresham, Ore.

Mr. F. H. Clark, General Superintendent of Motive Power of the Chicago, Burlington & Quincy Ry., has been appointed to a similar position on the Baltimore & Ohio Ry., succeeding Mr. J. D. Harris, resigned. He will be succeeded by Mr. F. A. Torrey, Superintendent of Motive Power for lines east of the Missouri River. Mr. Clark entered the service of the Burlington line in 1894, and was successively Chief Draftsman, Mechanical Engineer, Superintendent of Motive Power (of lines east of the Missouri), and (in 1905) General Superintendent of Motive Power.

Mr. Charles H. Markham, President of the Gulf Refining Co., of Pittsburg, Pa., formerly Vice-President and General Manager of the Southern Pacific Ry., has been elected President of the Illinois Central R. R. to succeed Mr. J. T. Harahan, who, having reached his 70th year, retires under the company's pension system. Mr. Markham entered the service of the Atchison, Topeka & Santa Fe Ry., as a section hand, in 1881. He was then 20 years old. Later in the same year he entered the station service of the Southern Pacific Ry. and was agent at various posts in the western country until 1891, when he became district freight and passenger agent at Fresno, Cal. From that time his rise in the operating and executive departments was rapid. In 1904, he became General Manager and Vice-President. The same year he left railroading to become General Manager of the Guffey Petroleum Co., of Beaumont, Tex.

Obituary.

David H. Valentine, a former member of the firm of Cranford & Valentine, contractors on many public works in the vicinity of New York City, died at his home in Brooklyn on Dec. 22. He was 65 years old and a director of many corporations.

Edgar N. Dickson, President and Treasurer of the Dickson Malleable Iron Co., of Milwaukee, Wis., died in that city on Dec. 20, aged 44 years. He had formerly been connected with the Allis-Chalmers Co. and the Northwestern Iron Co.

Samuel Bingham McKee, for many years a member of the American Society of Civil Engineers, died at his home in Los Angeles, Cal., on Nov. 29. He was born at Moriah, Essex Co., N. Y., on March 2, 1849. He was engaged in railway work with the Canadian Pacific Ry., the Ontario & Western R. R. and the West Shore R. R. for a number of years. He was also connected at various times with Witherbee, Sherman & Co. in iron mining, and with P. Sanford Ross, contractor, of Jersey City, N. J. In 1901 he was obliged to give up active practice and go to Arizona on account of his health. From there he went to Los Angeles. A widow and four sons survive him.

Brig.-Gen. Jared A. Smith, Corps of Engineers, U. S. A., retired, died from lung fever at his home in Cleveland, Ohio, on Dec. 17. He had been in ill health for some months, but his condition had not been serious until the last two weeks. He was born in Wilton, Me., on July 6, 1840. He graduated from West Point Military Academy in 1862, and was commissioned Second Lieutenant of Engineers. He went at once to the front and was assigned to the staff of Maj.-Gen. Banks, commanding the Second Corps of the Army of the Potomac. In August of the same year he was disabled in an attack of the Confederates upon a railway train. He was then assigned to duty as an Assistant Professor at West Point. Since 1865, Gen. Smith had had charge of numerous public works, many of which were in the vicinity of Detroit, Mich. From 1898 to 1901, he was stationed in California, where he was a member of the board of engineers on the improvements at Sacramento and for the establishment of harbor lines at San Francisco and other Pacific ports. From 1901 to 1903, he was in charge of the government work in the Delaware River. He was retired in 1903, and since then had made his home in Cleveland.

Gen. Smith soon became one of the most useful and public-spirited citizens of his home city. Since 1905, he had been a member of the County Building Commission, where his expert knowledge and long experience made him very valuable to his fellow citizens. He was also a member of the Chamber of Commerce of Cleveland, a member and Past-President of the Cleveland Engineering Society, and a member of other organizations. He leaves two sons, Dr. Geo. S. Smith, of Cleveland, and Capt. G. H. B. Smith, U. S. A.

Engineering Societies.

COMING MEETINGS.

CANADIAN SOCIETY OF CIVIL ENGINEERS.
Jan. 2-6. Annual meeting at Winnipeg, Man. Secy., C. H. McLeod, 413 West Dorchester St., Montreal, Que.

MICHIGAN ENGINEERING SOCIETY.
Jan. 10-12. Annual meeting at Lansing, Mich. Secy., Alba L. Holmes, Grand Rapids, Mich.

INDIANA ENGINEERING SOCIETY.
Jan. 12-14. Annual meeting at Indianapolis, Ind. Secy., Charles Brossmann, Indianapolis, Ind.

MONTANA SOCIETY OF ENGINEERS.
Jan. 12-14. Annual meeting at Helena, Mont. Secy., Clinton H. Moore, Leyson Block, Butte, Mont.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.
Jan. 17. Annual meeting at Pittsburg, Pa. Secy., Elmer K. Hiles, 803 Fulton Bldg., Pittsburg, Pa.

AMERICAN INSTITUTE OF ARCHITECTS.
Jan. 17-19. Annual convention at San Francisco, Cal. Secy., Glenn Brown, the Octagon, Washington, D. C.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
Jan. 18-19. Annual meeting at New York City. Secy., Charles Warren Hunt, 220 West 57th St., New York City.

ILLUMINATING ENGINEERING SOCIETY.
Jan. 20. Annual meeting at New York City. Secy., P. S. Miller, 29 West 39th St., New York City.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.
Jan. 24-26. Annual meeting at New York City. Secy., W. M. Mackay, P. O. Box 1818, New York City.

OHIO ENGINEERING SOCIETY.
Jan. 24-26. Annual meeting at Columbus, Ohio. Secy., C. J. Knisely, New Philadelphia, Ohio.

ILLINOIS SOCIETY OF ENGINEERS AND SURVEYORS.
Jan. 25-27. Annual meeting at East St. Louis, Ill. Secy., E. E. R. Tratman, 1636 Monadnock Block, Chicago, Ill.

NATIONAL BRICK MANUFACTURERS' ASSOCIATION.
Feb. 6-11. Annual convention at Louisville, Ky. Secy., T. A. Randall, Indianapolis, Ind.

NEW ENGLAND ASSOCIATION OF GAS ENGINEERS.
Feb. 15. Annual meeting at Boston, Mass. Secy., N. W. Gifford, 26 Central Square, East Boston, Mass.

MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK.—At the meeting of Dec. 28, a paper on "The Construction of the Croton Falls Reservoir of the New York City Water Supply," was presented by Mr. Frederick S. Cook, of New York City.

AMERICAN SOCIETY OF CIVIL ENGINEERS.—Three meetings for topical discussion will be held Jan. 20 and 21 at the Society's House in New York City. The general subject for the three meetings is to be road construction and maintenance. All engineers, whether members of this Society or not, are invited to attend. At the first meeting, on the morning of Jan. 20, three subdivisions will be taken up: (1) Preliminary investigations. (2) Relative value of three methods of carrying on work; (a) that in which both labor and material are furnished by the contractor, (b) that in which the material is supplied by the party of the first part and the labor by the contractor, (c) that in which both labor and material are supplied by the party of the first part. (3) Systems of maintenance. The discussion of the three divisions will be introduced respectively by Logan W. Page, Harold Parker and Hubert K. Bishop.

At the second meeting, on the afternoon of Jan. 20, the subdivisions taken up will be the use of water, calcium chloride, light oils, etc., as dust palliatives, and surface treatment with tars, heavy oils, etc. The discussion will be introduced by Samuel Whinery and Charles W. Ross.

The use of bituminous materials by penetration and by mixing methods will be the subject for the third meeting, on the morning of Jan. 21, at which the discussion will be led by Walter W. Crosby and Arthur H. Blanchard.